MAY 1998

BMP
Retrofit
PILOT PROGRAM

SCOPING STUDY, DISTRICT 11

Prepared For:

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1.0 PROJECT OVERVIEW

1.1 RESEARCH OBJECTIVES

The objectives of the stormwater retrofit pilot studies include an evaluation of the constituent removal efficiency, technical feasibility, and costs of constructing and maintaining Best Management Practices (BMPs). This study will document the constituent removal effectiveness of selected BMPs. The monitoring program will be supplemented with detailed records of siting, design, construction, and operational & maintenance issues and problems. A focus will be on documenting operational problems and procedures, determining solutions to such problems, and documenting operational procedures that promote or maintain the effectiveness of the BMP. Construction of a number of these devices will allow Caltrans to develop accurate cost estimates for potential BMP deployment. The costs will be assessed through detailed records kept on the process of designing, building, operating, and maintaining each of the retrofit devices.

1.2 SITE SELECTION

1.2.1 Background

As part of the Caltrans District 11 Retrofit Pilot Program, five projects comprised of multiple BMPs at multiple sites are to be constructed in the urbanized area of San Diego County. The types of BMPs proposed as pilot projects within the District include biofiltration strips, biofiltration swales, infiltration basins, infiltration trenches, media filters, extended-detention basins, and a wet basin. The total construction cost for all pilot projects within District 11 must be at least $2.5 million.

Each pilot project site has been selected while keeping in mind its appropriateness to the type of best management practice to be evaluated, and without pre-judgment about the outcome of the study.

Specific criteria outlined in the Consent Decree and used in siting of the Retrofit Pilot Projects include:

1. Hydraulic proximity to sensitive receiving waters;
2. Potential for improvements in water quality, including without limitation water quantity effects;
3. Technical feasibility;
4. Integration with other scheduled activities; and
5. Cost reasonableness.

Sites have been considered along Caltrans freeways and highways, maintenance stations and park and ride lots within the urbanized San Diego County area of District 11. Primary emphasis has been given to sites within a target watershed as defined in Section 1.3 of this chapter. Secondary emphasis has been given to sites within a defined priority alternative watershed also as discussed in Section 1.3 of this chapter.

1.2.2 BMP Retrofit Pilot Program

Caltrans will undertake five retrofit pilot projects in District 11, comprised of seven types of proposed BMPs. Caltrans will develop and implement a coordinated pilot program to test the feasibility and effectiveness of designing, constructing, maintaining and operating the selected BMPs. The five retrofit projects, proposed site locations and estimated construction costs are summarized in Table 1-1. Siting of the Pilot Projects is the subject of a separate report entitled, *Retrofit Pilot Program Proposal and Composite Siting Report, Caltrans District 11.*

1.2.3 General Project Criteria

For each project defined in Table 1-1, Caltrans will design, construct, maintain and monitor the BMP system. The objectives of the program will be as follows:

1. Determine the feasibility of design, construction and maintenance of the selected BMPs;
2. Evaluate the performance of the selected BMPs in removing constituents of concern in highway storm water runoff; and
3. Evaluate the frequency and magnitude of operational problems associated with maintenance of the structures and maintenance and safety concerns specific to transportation facilities, with an eye toward identifying solutions to problems that arise.

Complete records of design, construction, operation, maintenance and monitoring will be kept as a part of the pilot study program for use in the development of a final report. The final report will describe the feasibility, performance and operational characteristics of the defined projects.

Table 1-1

Project/ Plaintiff	Description	Target or Secondary Watershed	Location	Construction Cost	
1	**Extended Detention Basins and Biofilter**				
Stipulation & Decree	Site 1: Extended Detention Basin	primary	Interstate 15 and Highway 78 Interchange	$	282,000
Decree	Site 2: Extended Detention Basin	primary	Northbound Interstate 5 and Manchester Avenue	$	282,000
Stipulation & Decree	Site 3: Biofiltration Swale	primary	Southbound Interstate 5 at Palomar Airport Road	$	75,000
			Project 1 Subtotal	**$**	**639,000**
2	**Infiltration Trench and Biofilters**				
Stipulation & Decree	Site 1: Infiltration Trench	primary	Carlsbad Maintenance Station	$	50,000
Stipulation & Decree	Site 1: Biofiltration Strip	primary	Carlsbad Maintenance Station	$	105,000
Stipulation & Decree	Site 2: Biofiltration Swale	primary	Highway 78 Eastbound at Melrose Place	$	75,000
			Project 2 Subtotal	**$**	**230,000**
3	**Extended Detention/Infiltration Basins**				
Decree	Site 1: Extended Detention Basin	secondary	Interstate 5 and Highway 56	$	282,000
Stipulation & Decree	Site 2: Infiltration Basin	primary	Interstate 5 Southbound and La Costa Blvd.	$	355,000
			Project 3 Subtotal	**$**	**637,000**
4	**Wet Basin**				
Decree	Site 1: Wet Basin	primary	Interstate 5 Southbound at Manchester Avenue	$	355,000
			Project 4 Subtotal	$	355,000
5	**Media Filters**				
Stipulation & Decree	Site 1: Media Sand Filter	primary	Escondido Maintenance Station	$	150,000
Stipulation & Decree	Site 2: Media Sand Filter	primary	Interstate 5 Southbound at Highway 78 Park/Ride	$	150,000
Decree	Site 3: Media Sand Filter	primary	Interstate 5 Northbound at La Costa Blvd. Park/Ride	$	150,000
Stipulation & Decree	Site 4: Compost Filter	secondary	Kearny Mesa Maintenance Station	$	200,000
			Project 5 Subtotal	**$**	**650,000**
Note:	Decree=Consent Decree				
			Construction Total - All Projects	**$**	**2,511,000**

Specific sites were carefully selected to assure that the data collected in this program are accurate and transferable. This requires that the monitoring program adhere to well developed protocols established for other Caltrans programs. In addition, a number of logistical and safety related issues must be included in the selection criteria. Criteria included in the Caltrans *Guidance Manual: Stormwater Monitoring Protocols* (LWA, 1997), and described in detail in Appendix A as appropriate, helped to ensure selection of the most appropriate monitoring locations. Specific siting guidelines are also provided with the retrofit pilot study descriptions that follow. The site selection process is described in detail in *Retrofit Pilot Program Proposal and Composite Siting Report, Caltrans District 11* (RBF, 1998).

The devices selected for evaluation in the Pilot Study will be designed, installed, operated, and maintained at state-of-the-art levels. The publication entitled, *Operation, Maintenance and Management of Stormwater Management Systems*, published by the Watershed Management Institute and the US EPA dated August 1997 will serve as the primary guide and reference for the development of the maintenance and operation program for the Pilot Projects. ‘State-of-the-art’ refers to what is considered to be the best technology and/or practice available to-date.

The designs will be selected following a review of the technical literature and interviews with persons familiar with the performance of these devices. In general and as applicable, the selected BMPs will be designed in accordance with the *Caltrans Planning and Design Staff Guide*, dated September 1996. One of the goals of the retrofit pilot program is to investigate the feasibility and effectiveness of the design and installation of BMPs as a part of typical Caltrans facilities using Caltrans design procedures.

Since an important element of this study is to develop an understanding of problems (and solutions to those problems) and issues which might be encountered in implementing a stormwater retrofit program, the design, bidding, and construction of these facilities will be conducted in a manner compatible with Caltrans procedures. The level of maintenance for each device will be consistent with what might reasonably be expected under normal operating conditions. Such maintenance practices will be at ‘state-of-the-art’ levels for each BMP pilot project. Installation and monitoring of these devices under realistic conditions will result in a more accurate assessment of constituent removal performance and identification of operational and maintenance issues.

1.3 TARGET WATERSHED FOR RETROFIT PROJECTS

Caltrans has proposed the Carlsbad Hydrologic Unit, as defined by San Diego Regional Water Quality Control Board, as the primary target watershed for locating and constructing the five retrofit pilot projects. If detailed site investigation of Caltrans right-of-way within the primary target watershed proved that no adequate sites for any of the five pilot projects could be found, some of the projects were located in other watersheds. The Penasquitos Hydrologic Unit was considered as a first alternative for locating the remaining pilot projects.

1.3.1 Target Watershed

The Carlsbad Hydrologic Unit is an area of approximately 210 square miles in northwestern San Diego County. All or portions of the cities of Carlsbad, Encinitas, Escondido, Oceanside, San Marcos and Vista are included in the watershed. The Carlsbad Hydrologic Unit consists of the following hydrologic areas and sub-areas: Loma Alta, Buena Vista Creek, El Salto, Vista, Agua Hedionda, Los Monos, Buena, Encinas, San Marcos, Batiquitos, Richland, Twin Oaks, Escondido Creek, San Elijo, Escondido, and Lake Wohlford. It contains a variety of sensitive water resources, including coastal lagoons and perennial and ephemeral freshwater streams.

Caltrans facilities within the Carlsbad Hydrologic Unit include portions of I-5 (Post Miles 36 - 52) between Oceanside and Solana Beach, State Route 78 (Post Miles 0 - 17) connecting I-5 and I-15, and I-15 (Post Miles 26 - 36). In addition there are two maintenance facilities located within the target watershed: Carlsbad and Escondido Maintenance Stations. All Caltrans facilities in the target watershed are located within the urbanized area of San Diego County.

1.3.2 Alternative Watersheds

Priority was given to the Penasquitos Hydrologic Unit as the secondary target watershed. Penasquitos Hydrologic Unit has an area of approximately 170 square miles. All or part of the cities of Del Mar, Poway and San Diego are within this watershed. The Penasquitos Hydrologic Unit consists of the following hydrologic areas and sub-areas: Miramar Reservoir, Poway, Scripps, Miramar and Tecolote. The Penasquitos Hydrologic Unit drains into Mission Bay (303(d) listing). Los Penasquitos Lagoon (303(d) listing) is located in the Unit.

Caltrans facilities within the Penasquitos Hydrologic Unit include portions of Interstate 5, 15 and 805, State Routes 52, 67 and 274, and the Kearny Mesa Maintenance Facility.

The siting process for pilot retrofit projects within District 11 was conducted in conformance with the *Caltrans Target Watershed Proposal*, with primary emphasis given to locating retrofit pilot projects within the target watershed.

1.4 REGULATORY STATUS OF CREATED WETLAND AREAS

There is a potential concern that stormwater BMPs that create 'wetland' areas may become jurisdictional and subject to control by the California Department of Fish and Game, and the U.S. Army Corps of Engineers by way of Section 1601 of the State Fish and Game Code, and Section 404 of the Clean Water Act respectively. These regulatory agencies are beginning to establish procedures whereby structural BMPs may be differentiated from jurisdictional wetlands.

Both the State Department of Fish and Game and the U.S. Army Corps of Engineers were contacted relative to the issue of stormwater BMPs becoming jurisdictional wetlands. Each agency indicated that constructed stormwater BMPs that may accrue wetlands characteristics (hydric soils, standing water for a period of longer than seven days each year, or wetland type vegetation) can be considered exempt from regulation providing the following conditions apply:

1. The area is not currently a regulated wetland or jurisdictional waters.

2. A maintenance program is developed for the stormwater BMP indicating the type of maintenance that will be performed, and the frequency of such maintenance.

3. The maintenance program is not abandoned. Should the established maintenance schedule of the BMP be abandoned, each agency reserves the right to declare the location jurisdictional, and subsequently regulate future activity (disturbance) of the site.

4. The agency is notified in writing of the location of the BMP, the responsible entity for maintenance, and the nature of the maintenance activity. The schedule is identified and an agreement is reached.

Maintenance programs for each of the BMPs described in the Retrofit Program that may develop wetlands characteristics will be developed and forwarded to the State and U.S. Army Corps of Engineers under the procedure described above. The procedure for exempting stormwater BMPs from jurisdictional control will be further clarified during the Retrofit Pilot Projects monitoring phase.

1.5 STORM SIZE AND SAMPLING FREQUENCY

Storm water samples for the appropriate BMPs will be collected to conduct both baseline and post-construction studies. Storm water samples for the appropriate BMPs will be collected from four storms per year, weather permitting. Samples taken will be representative of the discharge resulting from a storm with greater than 0.1 inch of accumulated rainfall. Storm events will be sampled that are separated by at least 48-hours, with an attempt to sample storms with a separation of up to 72-hours of dry weather from the previous storm event.

1.6 LABORATORY ANALYSIS

The stormwater BMPs will be monitored to determine their constituent removal effectiveness. Each of the designs is focused on the removal of certain constituents present in highway runoff; consequently, the type of analyses performed will depend on the runoff control or BMP under consideration. Water quality samples from runoff controls which are designed to remove a wide range of constituents will be analyzed for solids, heavy metals, nutrients, and oil & grease. A list of these constituents is contained in Table 1-2. The samples from other, more specialized controls will be analyzed for the appropriate subset of these constituents.

Since these constituents may impair beneficial uses of receiving waters at extremely low concentrations, it is important that analytical methods be selected which have appropriate detection limits. In addition, many of the water quality samples will be collected after treatment by a BMP and will have concentrations below what is normally found in untreated highway runoff. The analytical methods recommended in Table 1-2 should provide accurate results at concentrations that might be expected in the discharge from retrofit BMPs.

Table 1-2: Methods for Analyzing Stormwater Constituents

Parameter	**Detection Limit (mg/l)**	Analytical Method **(USEPA,1979;1994)**
Total suspended solids	1	160.2
Zinc	0.001	289.2/200.8
Lead	0.001	239.2/200.8
Copper	0.001	220.2/200.8
Nitrate nitrogen	0.01	353.3
Total Kjedahl nitrogen	0.1	351.3
Total Phosphorus	0.002	365.2
Fecal Coliform	200 CFU	SM 909C*
Petroleum Hydrocarbons**	0.25 to 0.75	8015 mod/ext.

*Standard Methods **Includes diesel and gasoline fractions when referenced throughout this report
** Total recoverable petroleum hydrocarbons

Note that testing for metals includes total and dissolved fractions.

1.7 SITE STORMWATER SAMPLING EQUIPMENT

Many of the pilot retrofit sites will be equipped with flow measuring devices, automatic samplers and rain gauges. A comprehensive maintenance plan must be followed to assure that measurements of flow and rainfall are accurate and that water quality samples are representative of the runoff.

The flow monitoring equipment must be calibrated according to manufacturer specifications. Flow meters typically contain moisture indicators that should be checked during each site visit, or at least once between each monitoring event. Any time a moisture indicator reads above the acceptable level, the desiccant should be replaced with new packets. The sensor should be inspected prior to each monitoring event. The sensor should be calibrated at any time the calibration appears to be needed based on observance of recorded flow data. The sensor cable will be inspected prior to each stormwater monitoring season.

Automatic sampling equipment will be calibrated according to manufacturer specifications to collect the desired sample aliquot. At a minimum, the calibration will be checked prior to each stormwater monitoring season. After each monitored event, the sample bottles will be checked to verify that the programmed sample volume was delivered to the sample bottles. If the volume is incorrect, the sampler will be recalibrated prior to the next monitoring event. Pump tubing in the samplers will be replaced annually.

Rain gauges will be installed and maintained according to manufacturer specifications. At a minimum, the gauge should be inspected, cleared of debris, and calibrated following the manufacturer-specified procedure prior to each stormwater monitoring season.

Each of the monitoring sites will be inspected after runoff events to evaluate the condition of the equipment and to perform routine maintenance. The samplers will be inspected to verify that trash and other debris are not obstructing the intake for the sampler. Solar panels will be inspected to ensure dirt and other debris is not limiting the amount of sunlight; batteries will be checked to determine that they are fully charged. Trash and other debris which collect in the storm drain near the sampling point will be removed so that flow estimates will not be affected.

A more comprehensive maintenance program will be developed starting during the design phase and continuing through construction of the pilot projects. It is anticipated that some of the maintenance criteria will be site specific and more practically compiled once the final design details for each site are known. The maintenance program will be state-of-the-art using current published guidelines.

The formal operation, maintenance and monitoring program will be developed during the timeframe shown on the master schedule. Program development for each specific BMP will begin with design, vector control will be a significant early emphasis of the process. Milestone dates for the maintenance and operation program are:

Milestone	Completion Date
Develop draft maintenance, operation, monitoring program and report	7/29/98
Plaintiff review of draft program and report	9/21/98
Final program published	10/22/98

1.8 MOSQUITO AND VECTOR CONTROL

Mosquitoes and vector control are concerns in South California metropolitan areas. For this reason, mosquito and vector control procedures will be developed once the retrofit projects are constructed and in operation. The assistance of a vector control specialist will be obtained to assist in the preparation of a program to address proper operation and maintenance procedures to minimize mosquito and vector problems. Vector control issues will be examined, at a minimum, for the following Pilot Projects: detention basins, wet basin and biofilters.

The vector control program will consist of a monitoring component to assess the potential for mosquitoes and related problems at the pilot sites. The monitoring program will also define appropriate abatement procedures (if any are required) to be used at the Pilot

Program sites. Plaintiffs will be updated relative to vector monitoring activities through quarterly reports as well as participate in the program formulation process.

1.9 BENEFIT ASSESSMENT PROGRAM AND REPORTING

Detailed records will be maintained for each site to document siting, design, construction, operation and maintenance experience. Many of the stormwater BMPs that will be monitored during this study, have been the subject of numerous research efforts. Consequently, the constituent removal for some of these devices is well established for properly designed and maintained systems. Therefore, much of the effort of this study will be directed to recording and analyzing the siting, design, construction, and operation and maintenance experience. Forms will be developed for each phase of the project so that engineers and support staff can record their observations in a common format to facilitate compilation of this information.

A site visit log will be developed prior to visiting potential sites. It will be based on a list of criteria, specific to the BMP objectives and will be filled out during each site inspection. Criteria to be documented during a site visit may include the type of site, drainage area characteristics, type of runoff, whether an appropriate sampling location exists, potential safety issues, site access, and whether accurate flow measurement is achievable.

Other forms will be developed in support of the Benefit Assessment Program. The observational and narrative description of the process will identify the problems encountered in siting, designing, constructing, operating and maintaining the facilities. In addition, it will document whether the design guidelines could be fully implemented and how that affected BMP performance. An analysis of these data will form a central part of the final research report for each of the selected BMPs. Emphasis in the final reports will be placed on identifying solutions to problems discovered during the implementation of the pilot projects, and documenting procedures that were determined to be beneficial in maintaining the effectiveness of the BMP. Specifically, the Benefit Assessment Program for the pilot projects will include the following elements:

1. Collection of stormwater samples (influent and effluent) for each pilot project except as modified herein using autosampler equipment. This will form the "Sampling Program."
2. Implementation of a "Maintenance Program" to ensure each of the pilot projects are maintained at state-of-the-art levels throughout the monitoring period. Specific maintenance checklists will be developed for each BMP and each site, to ensure that improper maintenance does not impair the operation of the BMP.
3. Implementation of an "Assessment Program" documenting: the deviations from standard design; compromises in design-based, on-site constraints; and deviations

from standard maintenance practices due to unusual weather, site conditions or failures.

4. Observation of BMP operation during storm and post storm periods (a minimum of four times per year) to assess such factors as: functioning of the outlet works; estimation of residence time, visual observations regarding ‘short circuiting;’ and drain time for infiltration BMPs. These observations will be a part of the “Assessment Program”.
5. Comparison of the performance of the pilot projects to that of other BMPs in similar projects, analyzing the reasons for differences where they occur. This will be presented in the Final Report.
6. Documentation of complete process including siting, design, construction and monitoring in a final report.

Sampling results and site conditions will be described for each sampled storm event. This data will be compiled in a database and presented in the final BMP pilot program project reports.

Appendix C provides a discussion of the proposed methodology for estimating constituent loadings and BMP efficiency for the pilot studies. The procedure indicated will be used to calculate average annual loads and removal efficiencies for the pilot projects where paired influent and effluent samples are collected.

1.10 SCHEDULE/COST

A master schedule has been prepared indicating the timeline for retrofit siting, design, construction bid, construction, monitoring, and final report development. This master schedule is contained in Appendix B. The three-year schedule with monitoring starting in the Fall of 1998 is a target schedule for all of the BMP Retrofit Projects. The fourth year will be used to prepare a report for submittal to either California State Water Resources Control Board or the Regional Water Quality Control Board, San Diego Region, whichever oversees Caltrans District 11’s current stormwater permit. A second, or contingency schedule has been developed that indicates monitoring beginning in the Fall of 1999 rather than 1998. The target schedule would allow for two monitoring seasons, while the contingency schedule will cover one monitoring season. Both schedules are consistent with the Consent Decree requirement of completing construction of five retrofit projects before June 30, 1999. It is expected that some of the pilot projects may be delayed due to unforeseeable circumstances, and would then proceed based on the contingency schedule time-frame. Due to the research nature of this program, all of the dates shown in the master and contingency schedules are considered estimates, and with the exception of those expressly defined in the Consent Decree, will be subject to revision as the program proceeds.

The determination of the specific pilot projects that will be moved to the contingency schedule will be made mutually between Caltrans and Plaintiffs at established decision points. The decision points are defined as: 1) at the completion of design (June 1998, see Appendix D) and 2) prior to monitoring (estimated November 1998). A formal staging plan, defining the decision points and the criteria used to review the specific pilot project schedule track at each decision point, is provided in Appendix D.

As shown in the master schedule, the total cost of the retrofit program, including siting, design, construction and monitoring is estimated to be about $6,400,000. The construction cost is estimated to be $2,511,000. Actual costs for the program will be accumulated as each of the scheduled milestones is completed. The actual program costs will be reported in the retrofit pilot project final report. The projects will be constructed by contractors through two construction bid packages.

The program schedules call for six milestone events over the next four years as follows:

Milestone	Completion Date (Mast. Sched)	Completion Date (Cont. Sched)
1. BMP Siting	January 9, 1998	May 4, 1998
2. BMP Design	May 4, 1998	August 19, 1998
3. Bid Projects	August 19, 1998	March 16, 1999
4. Construction	November 30, 1998	June 22, 1999
5. Monitoring	April 1, 2000	April 1, 2000
6. Final Report	January 10, 2001	January 10, 2001
7. Retrofit Report	January 10, 2002	January 10, 2002

The seventh milestone event indicated in the table, the retrofit report, will be prepared for the Regional Water Quality Control Board as a summary report for the District 11 Retrofit Study. This report is not formally a part of the BMP Pilot Retrofit Program, but is shown here for information.

Other intermediate milestones are shown on the master schedule. Estimated costs for each of the milestones and the associated components are provided in the schedule. The master schedule also indicates the timing of periodic status reports and meetings between Caltrans, NRDC, US EPA and Baykeeper.

Periodic status reports and meetings will be held to update the Plaintiffs on the progress of the program and receive input as to suggested changes or modifications in the program. Status meetings have been scheduled on a regular basis to coincide with general project milestones or periods of significant activity. The status meetings will also be used as an opportunity to achieve consensus relative to the Benefit Assessment Programs previously described. The scheduled periodic status meetings (per the Master Schedule) and the primary topic of each meeting are:

Scheduled Date	Primary Topic
March 30, 1998	Pilot Project Design
September 1, 1998	Review Bids/Sampling Program
December 1, 1998	Maintenance Program/Assessment Program
March 30, 1999	Review First Season Monitoring Data
September 1, 1999	Review Benefit Assessment Programs[1]
December 1, 1999	Review Benefit Assessment Programs[1]
March 30, 2000	Review Second Season Monitoring Data
September 1, 2000	Review Final Report Format
December 1, 2000	Review Report Progress

[1]As needed/appropriate

Status reports will be prepared prior to each meeting to provide background for discussion. The status reports will be provided to Plaintiffs two to three weeks prior to the status meeting to allow for discussion comments on the report at the meeting. Meeting minutes will be prepared for the status meetings documenting the discussion and the agreed modifications to the program. One of the purposes of the status meetings is to provide flexibility within the program to respond to information as it is developed, allowing the program to evolve in a systematic manner.

A detailed project schedule will be prepared and maintained by Caltrans to track the: 1) major decision points defined herein, 2) deliverables to the Plaintiff, 3) internal project deadlines and 4) delivery and response dates for work items to the Plaintiffs. Further, the detailed project schedule will include other projects proceeding under the terms of the Caltrans Districts 7 and 11 litigation to provide a more comprehensive view of the overall program activities. The detailed project schedule will be regularly updated and available through the quarterly reports and the internet. Items specifically addressed at the periodic status meetings and/or on the detailed project schedule are as follows:

- Detailed design basis reports, with date for final approval of construction plans *
- Construction status reports (monthly during construction periods) *
- Operational plans (by project site or site group of the same project type),

including--

-- Operating procedures

-- Maintenance plan (procedures and schedule)

-- Benefits assessment plan (observations, measurements, water quality monitoring, etc.), including methods, schedules, anticipated data analysis techniques, etc.

- Operational status reports--covering operating actions, maintenance performed, and benefits assessment activities (quarterly during operational periods) *

- Reports on problems encountered--description, potential solutions considered, solutions attempted, results of attempts, conclusions and recommendations (quarterly) *

- Cost accounting (by site and categorized by site selection, design, construction, operation, maintenance, benefits assessment) *

- Compilation of correspondence with external parties such as special consultants (quarterly) *

* If it is appropriate to time submissions with status meetings, reports on these elements can be submitted with status reports prepared for meetings organized according to this framework.

1.10.1 Workload Allocation

The design, construction management, maintenance, monitoring and operation of the retrofit projects will be divided between two consulting firms as shown on the Master Schedule. The projects have been grouped into two construction bid packages to create discrete construction projects that will attract reputable construction firms.

Robert Bein, William Frost and Associates (RBF) and Kinnetic Laboratories will oversee the two construction packages. RBF will provide design services as well as construction management. Kinnetic Laboratory will assume responsibility following construction, completing the monitoring tasks and final report.

2.0 RETROFIT STUDIES

2.1 EXTENDED DETENTION BASINS

The objective of extended detention basins is to remove particulate constituents. The water quality benefits are the removal of sediment and buoyant materials. Furthermore, nutrients, heavy metals, toxic materials, and oxygen-demanding particles are also removed with associated particles. The control of the maximum runoff levels serves to protect drainage channels below the device from erosion and to reduce downstream flooding. However, the subject basins will not be designed for peak flow attenuation and control of peak discharge, rather they will be designed using guidance relative to water quality operation. At minimum, vegetation at the bottom of the basin will be managed before the start of the monitoring period per the California Department of Fish and Game permit #5-261-97 to prevent classification of the basin as a wetland.

2.1.1 Site Selection (Young et al, 1996)

Normally, the land required for an extended detention basin is approximately 0.5 to 2.0 percent of the total tributary development area. Although the soil types beneath the pond seldom prevent the use of this BMP, they should be considered during design. Any exfiltration capacity should be considered a short-term characteristic because exfiltration will decrease over time as the soil is clogged with fine sediment. In areas with very coarse soils, detention basins can be constructed of concrete or lined with compacted clay.

The runoff that is subject to this BMP should originate as much as possible within the highway right-of-way. Since rights-of-way are typically narrow, highway extended detention dry ponds are likely to be long and narrow. They can be located on the sides of highways next to the shoulders. They can also be located in the lands around intersections where not precluded by safety considerations.

Curb and gutter sections are ideal catchments to maximize on-site and minimize off-site drainage to highway BMPs, as are bridge deck systems. Extra area may be needed to accommodate this BMP, and this requirement should be factored into preliminary design and retrofit activities. Figure 1 shows how an extended detention pond may be located within a highway right-of-way.

The selected Extended Detention Basin Sites are located at the interchange of SR 56 and I–5, at I–5 and Manchester Avenue (northbound), and at the interchange of SR 78 and I-15. Further information relative to the sites is referenced to a report entitled, *Composite Siting Study, District 11*, dated February 1998, prepared by Robert Bein, William Frost and Associates.

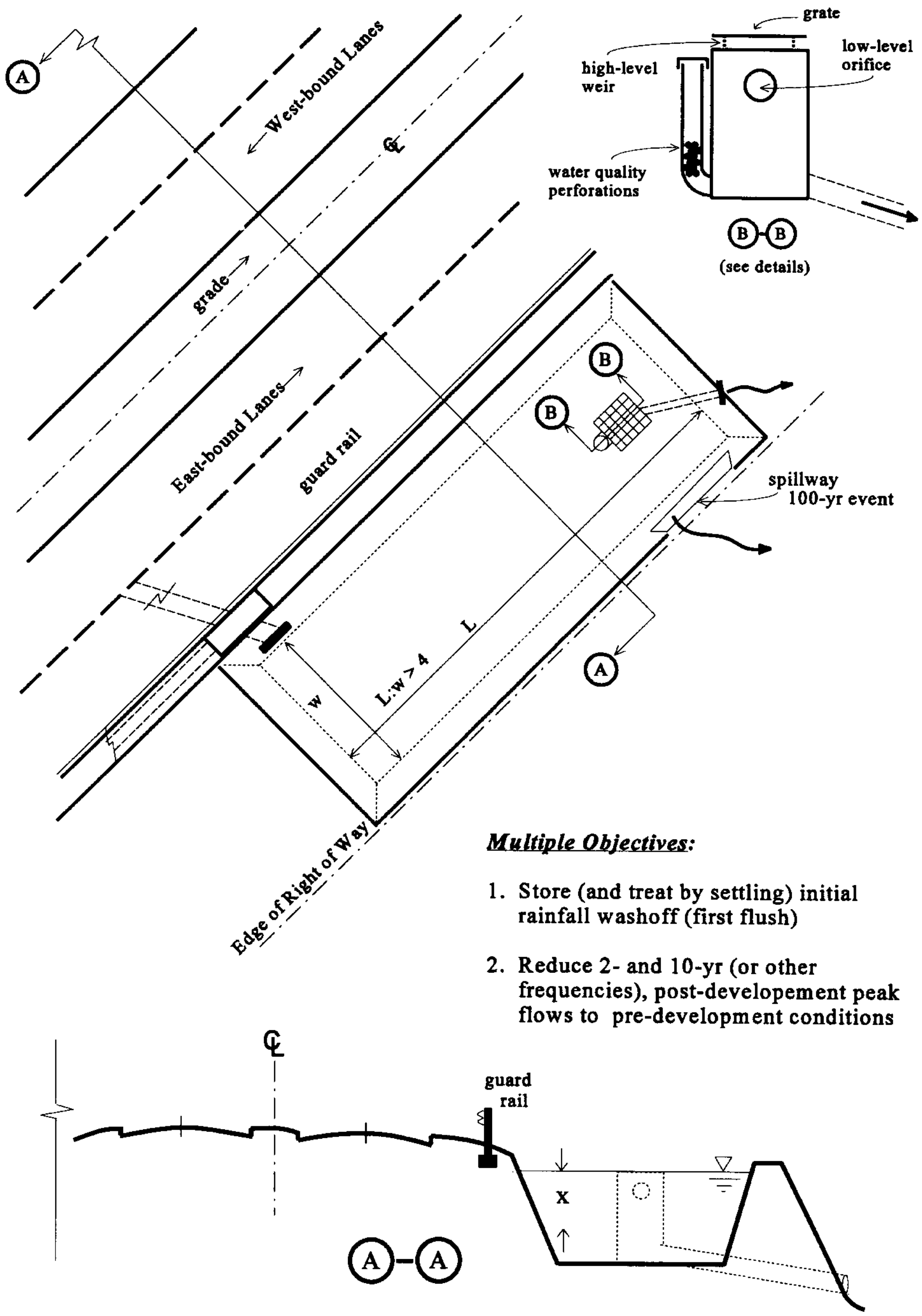

Figure 1 Schematic Of An Extended Detention Pond

2.1.2 Design Guidance

Estimating the appropriate dimensions of a BMP facility involves a trial and error process in which the designer tries to fit the required BMP volume so that it works well with the site configuration. Each site has its own unique limiting factors. Some constraints other than the existing topography include, but are not limited to, the location of existing and proposed utilities, depth to bedrock, and location and number of existing trees. The designer can analyze possible basin configurations by varying the surface area and depth and then determining the corresponding available storage (Young et al, 1996).

In order to enhance the effectiveness of extended detention basins, the dimensions of the basin must be appropriately sized. Merely providing the required storage volume will not ensure maximum constituent removal. By effectively configuring the basin, the designer will create a long flow path, promote the establishment of low velocities, and avoid having stagnant areas of the basin. To promote settling and to attain an appealing environment, the basin design should consider the length to width ratio, cross-sectional areas, basin slopes and pond configuration, and aesthetics (Young et al, 1996).

Caltrans has identified a number of criteria to be applied to basin design (CDM et al, 1997):

Access: A permanent area will be provided around the perimeter of the impoundment to allow maintenance. Provisions will also be made for emptying the basin as necessary for maintenance.

Volume: Caltrans has adopted a maximum design goal of sizing detention basins to capture the entire runoff from a one-year, 24-hour storm event. Determine the one-year, 24-hour storm event for either the closest rain gauge to the project site, or the average of the closest 2-3 gauges, particularly where there is a significant elevation difference between the closest gauge and the project site (see Sheet 1, Appendix C, Staff Planning and Design Guide). The runoff produced by this storm based upon the characteristics of the project drainage area after completion of the project should then be calculated and the resulting volume used as a maximum design target. A smaller design storm may be used based on site specific conditions.

Detention Time: Extended detention basins require longer detention times to provide the opportunity for sediment particles in the runoff to settle out of the water column. Detention facility studies indicate that effective detention basins should be designed for a detention time of 24 hours for average conditions rather than full basin conditions. In California, a 24-hour average detention time for the full range of storms up to and including the water quality design storm is generally achieved with a full-basin drawdown time of from 48 to 72 hours, where the drawdown time is the time required for a full basin to empty. Although longer detention times improve constituent removal in the basins, there is a tendency for the smaller outlet structures to clog with litter, grass clippings and other debris (Barrett et al, 1997).

Basin Geometry: The configuration of the basin, as well as the location of the associated facilities (inlet, outlet structures, baffles, etc.), will significantly impact the desired function of the basin. In order to enhance constituent removal, the hydraulic flow length of the basin will be maximized. The length to width ratio of the basin will be on the order of 3:1 or greater depending on the site configuration. Pond depths range from 1.2 m (4 ft) to 1.8 m (6 ft) (CDM et al, 1996).

Basin Side Slopes: Embankment slopes will be stable and gentle enough to limit rill erosion and facilitate maintenance access and needs. Although limited by the stability of the soil, basin slopes should be 4:1 or flatter. Steeper slopes may require that the facility be fenced for safety, although basin side slopes should not exceed 2:1. Embankment slopes will be compacted and stabilization of slopes provided to assist in preventing erosion. Height limitations should be in accordance with HDM Index 829.9 and verified by the Division of Dam Safety.

Inlets: Inlet structures will be designed to dissipate flow energy at the inlet point to limit erosion and promote particle sedimentation. They will be located as far as possible from the outlet structure to maximize the hydraulic flow path (CDM et al, 1996).

Outlet: Energy dissipation will be constructed at outlets where systems discharge to earth channels. The relatively ‘clear’ flow (reduced sediment load) discharged by BMPs could have the propensity to scour natural or constructed earth receiving channels under some conditions. The scour potential in the receiving channel will be assessed, and appropriate mitigation measures taken for each site. Possible mitigation includes the construction of an engineered energy dissipater such as an impact basin, or the construction of riprap lining.

Maintenance Considerations: Maintenance procedures also will be considered during the design stage. Basins will be located such that safe and easy access for maintenance is provided. Debris in empty basins may be unsightly and require more frequent maintenance. In some areas, mosquitoes and other insects may require additional maintenance requirements (CDM et al, 1996).

Safety: Safety is a major consideration when planning retention/detention basins. Basins will be located where failure would not cause loss of life or property damage. District 11 Composite Siting Study (RBF, 1998) describes specific safety criteria used during site selection process. The size of the basins will be kept below the threshold that would require approval from the State Division of Safety of Dams, which is less than 50 acre-feet of storage and a 25 foot embankment height, or unlimited storage and a maximum 6 foot embankment height.

2.1.3 Maintenance

Periodic removal of sediments will be required to maintain the basin stormwater capture volume and to remove undesirable or excessive vegetation growth. Maintenance access to the basin invert will be provided for this purpose. The outlet structure and debris rack should also be inspected prior to each storm event.

2.1.4 Water Quality Monitoring

Constituent removal in the extended detention basin will be determined by comparison of the average water quality of runoff entering the facility with that leaving (see Appendix C). Automatic sampling equipment will be installed at the inlet and outlet of the device to collect flow weighted composite samples. These sites will be designed to incorporate flow measurement structures.

The most appropriate flow measurement structures for basin inlets are Parshall flumes and H flumes. An advantage of these devices is their ability to pass trash and other debris, which tend to accumulate in structures such as V-notch weirs. The high velocity through the flume prevents sediment accumulation from runoff with high suspended solids concentrations. In addition, these devices operate with a much smaller head loss than a weir. Depending on the size of the contributing watershed, an H flume is preferred because of its ability to accurately measure a wider range of flows.

Flow measurement at the basin outlet is subject to different constraints than at the inlet. Because of the long detention times, flow rates will necessarily be much lower and most of the trash and debris will have been removed from the runoff. Therefore, a V-notch weir is the preferred option for measuring flow at this location. The type and size will be determined by the size of the watershed and expected discharge rate from the basin.

The runoff samples collected by the automatic sampling equipment will be analyzed for:

- total suspended solids (TSS),
- zinc,
- lead,
- copper,
- nitrate nitrogen,
- total Kjedahl nitrogen, and
- total phosphorus.

Manual grab samples will also be collected during selected storm events to determine the instantaneous concentrations of:

- total petroleum hydrocarbons, and
- fecal coliforms.

At the end of the monitoring period, samples of the sediment that has been retained by the basin will be collected and analyzed to determine the proper disposal method.

Vegetation changes in the basins will be documented over the monitoring period. Standard botanical techniques will be used to record vegetation cover once during each growing season.

2.1.5 Schedule/Cost

Following is a list of milestone dates (target schedule) for the Extended Detention Basin Pilot Project (Project 1 and 3 [partial]):

1. Sites Selection complete: 1/9/98
2. Design complete: 5/5/98
3. Project Bid Complete: 8/13/98
4. Construction Complete: 11/30/98
5. Monitoring: 12/01/98 through 3/30/00
6. Final Report Complete: 1/01

Construction cost for the Extended Detention Basin pilot projects is estimated to be $282,000 per site. A total of three basins will be constructed as a part of the District 11 program (Projects 1 and a portion of Project 3 as shown on the Master Schedule) for a total cost of $846,000.

2.2 INFILTRATION BASINS

Infiltration basins are similar to detention basins, except that they have a high flow spillway only and no standard outlet structure. The incoming stormwater runoff is stored until it gradually exfiltrates through the soil of the basin floor.

2.2.1 Site Selection (Young et al, 1996)

The location for placement of an infiltration basin must be carefully chosen. One of the most important aspects of a site is the type of soil. Other factors which are important in the site selection include slope, bedrock depth, and depth to the water table. In general, only SCS Type A and B soils have high enough infiltration rates to permit drainage of the basin without excessive clogging. Soils composed of more than 30% clay or 40% combined silt and clay are undesirable. Soil cores should be taken to a depth of at least 1.5 m (5 ft) below the proposed basin floor elevation to determine which kinds of soils are prevalent at the potential sites. The basins should also be a minimum of 0.6 to 1.2 m (2 to 4 ft) above the seasonally high water table. They should not be located within 30 m (100 ft) of drinking water wells to avoid any possible contamination (Schueler, 1987). The basins should also be a minimum of 3m (10 ft) down-gradient and 30 m (100 ft) up gradient from building foundations because of possible seepage problems. In addition, the basins should be located down gradient from highway pavement to avoid infiltration to the pavement edgedrain system (Young, 1998).

The selected infiltration basin site is located along I-5 at La Costa Boulevard (southbound). Further information relative to the site is referenced to a report entitled, *Composite Siting Study, District 11*, dated February 1998, prepared by Robert Bein, William Frost and Associates.

2.2.2 Design Guidance (Young et al, 1996)

Drainage Area. Drainage areas between 2 and 20 ha (5 to 50 ac) are good candidates for infiltration basins. Smaller areas are better served by infiltration trenches (Schueler, 1987).

Volume. The basin will be able to exfiltrate the design storm volume (see Sheet 1, Appendix C, Caltrans Planning and Design Staff Guide) from the contributing watershed (smaller storms can be considered based on site specific conditions). The optimum configuration places the basin off-line so that additional runoff is routed around the basin, rather than displacing the captured first flush volume (Horner, 1996, p. 10). However, site design constraints may limit the feasibility of this option.

Slope. The basin floor will be as flat as possible to ensure an even infiltration surface. Side slopes will have a maximum slope of 2:1.

Avoidance of Compaction. Compaction during construction will be avoided if possible by excavating from the sides of the basin as opposed to from the basin floor. If using equipment on the basin floor is unavoidable, light equipment will be used, and the floor will be deeply tilled with a rotary tiller or disc harrow upon completion of excavation. This should be followed by a pass with a leveling drag (Schueler, 1987). Another useful reference on techniques to avoid compaction is *Fundamentals of Urban Runoff Management: Technical and Institutional Issues,* Richard Horner, et. al., p. 33-34.

Vegetation. Vegetation will be established if possible. Root penetration and thatch formation maintains and sometimes improves infiltration capacity of the basin floor. In addition, the vegetation helps to trap the constituents by growing through the accumulated sediment and preventing resuspension.

Inlet. An energy dissipation device will be installed to reduce inflow velocities, trap sediment upon entrance to the basin, and distribute flow evenly over the floor. The inlet pipe or channel will enter the basin at floor level to prevent erosion.

Safety: Safety is a major consideration when planning infiltration basins. Basins will be located where failure would not cause loss of life or property damage. District 11 Composite Siting Study (RBF, 1998) describes specific safety criteria used during site selection process. The size of the basins will be kept below the threshold that would require approval from the State Division of Safety of Dams, which is less than 50 acre-feet of storage and a 25 foot embankment height, or unlimited storage and a maximum 6 foot embankment height.

A schematic of an off-line infiltration basin is shown in Figure 2.

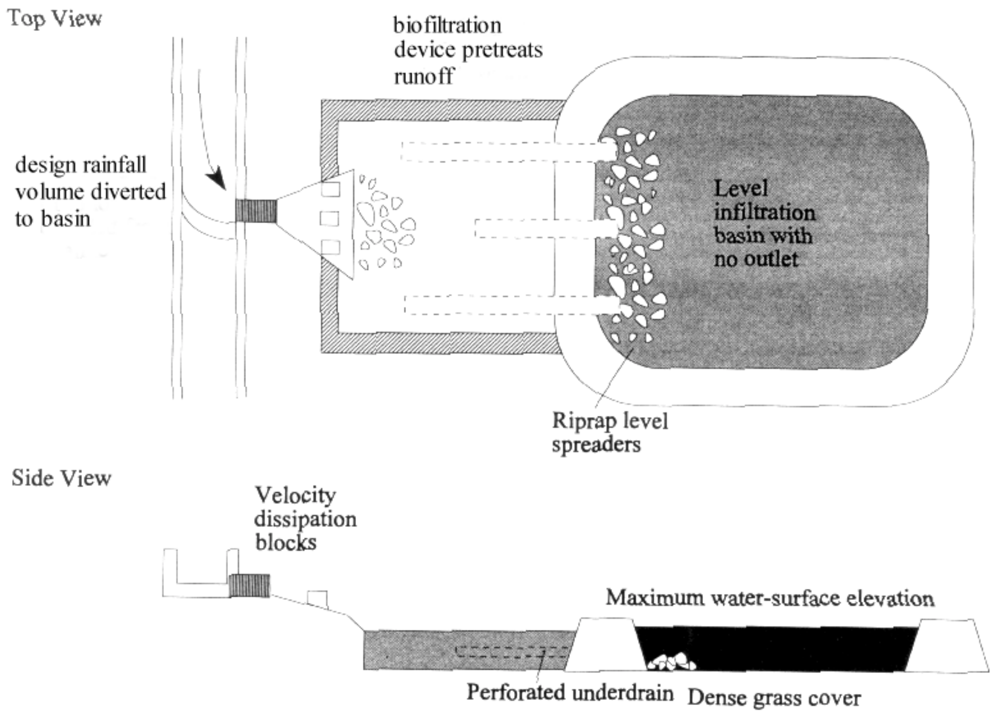

Figure 2 Schematic Of Infiltration Basin Design

2.2.3 Maintenance

Infiltration basins must be periodically cleaned to remove trapped sediments and restore permeability. Over the course of operation, fines will accumulate on the basin invert creating a relatively impervious veneer that reduces the average infiltration rate. The deposits must be removed from the basin when the infiltration time for the design storm volume exceeds 72 hours. Vegetation must also be managed to prohibit excessive amounts that would reduce the stormwater volume, moderate vegetation is generally seen as a positive attribute for infiltration devices as it can aide in maintaining permeability of the soil and assist in the uptake of some soluble constituents.

2.2.4 Water Quality Monitoring

The monitoring program is designed to address three main questions related to the use of infiltration basins: 1) What is the degree and rate of infiltration? 2) Is constituent removal sufficiently high in the basin to avoid contamination of groundwater? and 3) How should the material that collects in basins be disposed?

The rate of stormwater infiltration will be measured by installing an automated flow meter in the basin. The meter will be a bubbler type device, which is available from a number of manufacturers. The meter will record changes in water depth in the basin so that infiltration rate can be calculated. The data will also indicate how the infiltration rate changes over the course of the study period and indicate when maintenance is required to remove material that has accumulated on the surface of the basin.

The method for determining the threat to groundwater supplies will depend on the depth to groundwater at the site. If the groundwater level is within about 10 m (33 ft) of the basin floor, a monitoring well will be constructed to allow water quality samples to be collected twice a year from the saturated zone. The well will be installed adjacent to the basin to prevent possible short-circuiting down the annulus of the well and to facilitate access and sampling. The samples will be analyzed for:

- zinc,
- lead,
- copper,
- nitrate nitrogen,
- total Kjedahl nitrogen,
- total phosphorus
- total petroleum hydrocarbons, and
- fecal coliform.

If the normal groundwater level is deep, then samples will have to be collected from the vadose zone. This type of sampling requires a pressure-vacuum lysimeter. The lysimeter will be installed according to the manufacturer's recommendations and placed so that samples are collected at a depth of 1-2 m (3-6 ft) below the basin floor. This type of sampling is only appropriate for the analysis of dissolved constituents, because the water must be drawn through a ceramic or Teflon cup.

Collection of sufficient sample volumes from the unsaturated zone is normally only possible following significant rainfall. Groundwater quality changes relatively slowly in response to changes in the characteristics of the recharged water, so an intensive monitoring program is not necessary. Samples will be collected twice each year, in December and February. Based on previous water quality monitoring of runoff from highways in the Los Angeles area, the main dissolved constituents that are of concern are heavy metals. Therefore, the samples will be analyzed for the zinc, lead and copper.

The rate of accumulation of material in the infiltration basins will be determined by making annual measurements at the end of the rainy season of depth of material in the basins. Sediment samples will be collected from the surface of the infiltration basin at the same time. The samples of sediment will be analyzed for particle size distribution, zinc, lead, copper, and total petroleum hydrocarbons. The sediment will be subjected to the appropriate analyses to determine the proper method of disposal.

Core samples in the infiltration basin will be collected to determine the rate at which constituents are transported into the subsurface. Samples of soil will be collected from depths of 0.3 m and 0.6 m (1 ft and 2 ft) in the infiltration basin and analyzed for zinc, lead, copper, and total petroleum hydrocarbons. Similar samples will also be collected and analyzed immediately following completion of construction for comparison.

Vegetation changes in the basin will be documented over the monitoring period. Standard botanical techniques will be used to record vegetation cover once during each growing season.

2.2.5 Schedule/Cost

Following is a list of milestone dates (from the target schedule) for the Infiltration Basin Retrofit Pilot Project:

1. Site Selection complete: 1/9/98
2. Design complete: 5/5/98
3. Project Bid Complete: 8/13/98
4. Construction Complete: 11/30/98
5. Monitoring: 12/1/98 through 3/30/00
6. Final Report Complete: 1/01

The total cost for construction of an infiltration basin is estimated to be $352,000. An infiltration basin will be constructed as a part of the District 11 BMP retrofit Pilot program (portion of Project 3) for a total construction cost of $352,000.

2.3 INFILTRATION TRENCH

Caltrans has identified a site in District 11 to construct an infiltration trench in the drainage pathway from a Caltrans maintenance yard. This device will be designed to infiltrate the majority of runoff to the saturated zone.

2.3.1 Site Selection

The following criteria suggested by Young et al (1996) were used to site the infiltration trench.

Several factors need to be considered when a potential infiltration site is being examined. The soil type and drainage area are two of the most important aspects of the site. A drainage area of between 0.4 and 4 ha (1 to 10 ac) is recommended. Other factors to examine include the slope of the watershed, the depth to bedrock and the seasonally high water table. The distance to wells and foundations must also be examined (Schueler, 1987). The bottom of the facility should be at least 1.2 m (4 ft) above the underlying bedrock and at least 0.6 to 1.2 m (2 to 4 ft) above the seasonally high water table (Yu and Kaighm, 1992).

Soil should have an infiltration rate greater than or equal to 7 mm/h (0.27 in/h) for practical design. Some suggest a minimum infiltration rate of 13 mm/h (0.5 in/h) (Yu and Kaighm, 1992; Schueler, 1992). This rate is associated with sand, loamy sand, sandy loam, loam, and silt loam soil groups. Soils should be tested at the site by taking a core to a depth of at least 1.5 m (5 ft) below the anticipated level of the stone reservoir bottom. The cores should be examined for anything that might inhibit infiltration, such as localized clay lenses, hardpans, or fragipans. Trenches should not be placed on “C” or "D" soils (soils with infiltration rates of less than 0.27 in/h), or on soils with a clay content greater than 30 percent. Placing an infiltration trench on C and D soils is questionable, and should only be considered if the trench is of the partial-infiltration type. Soils with a combined silt/clay content greater than 40 percent are also not good sites for infiltration trenches (Schueler, 1987). In-field infiltration tests are being conducted on potential infiltration basin sites for this pilot program.

Trenches should not be placed in sites where the incoming drainage area has a slope greater than 20 percent. The slope of the trench bottom should be approximately zero, unless an outlet placed at the bottom of the trench is part of the design (Schueler, 1987).

The selected site is located at Carlsbad Maintenance Station. Further information relative to the sites is referenced to a report entitled, *Composite Siting Study, District 11*, dated February 1998, prepared by Robert Bein, William Frost and Associates.

2.3.2 *Design Guidance*

Infiltration trenches and infiltration basins follow similar design logic. The differences are that the former is for small drainage areas and stores runoff out of sight within a gravel or aggregate matrix, whereas the latter is for larger drainage areas and water is stored in a visible surface pond.

Infiltration trenches can be categorized both by trench type, and as surface or below ground. Trench types include *complete, partial, and water quality* infiltration trenches. A schematic of a typical infiltration trench is shown in Figure 3.

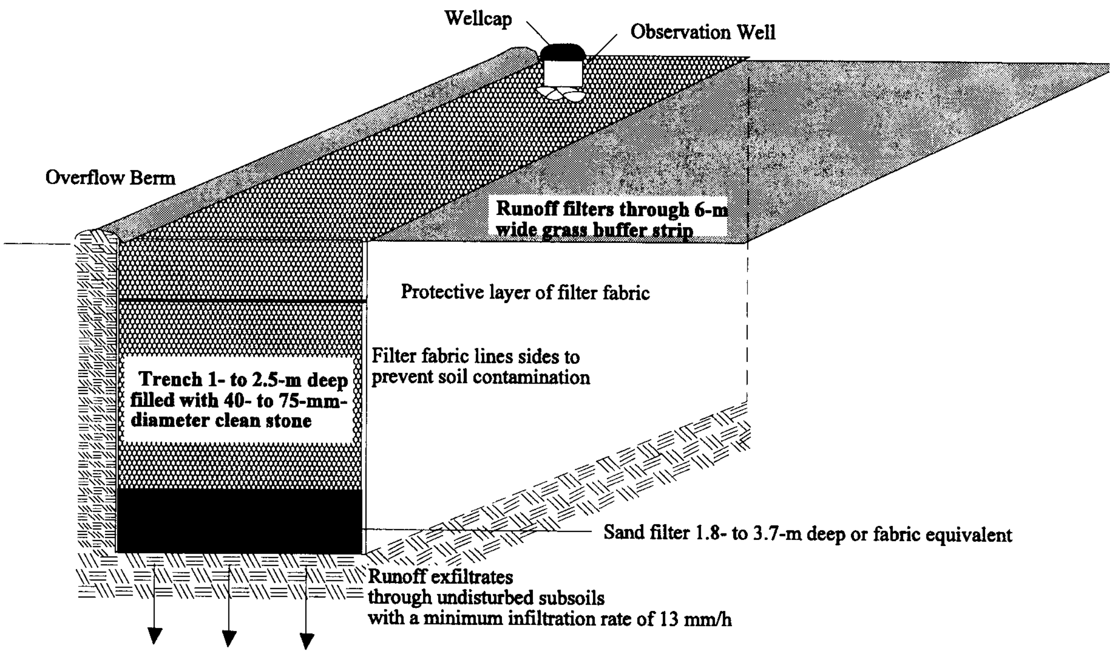

Figure 3 Cross-Section Of An Infiltration Trench

Volume. Trenches will be sized using the design storm approach (see Sheet 1, Appendix C of the Caltrans Planning and Design Staff Guide for volume calculation).

Dimensions. Generally, soils with low infiltration rates require a higher ratio of bottom surface area to storage volume (Northern Virginia Planning District Commission and Engineers and Surveyors Institute, 1992).

The actual storage volume of the facility is the void ratio multiplied by the total volume of the trench. Constraints such as available land, depth to bedrock, and height of the water table are used to determine the final dimensions of the trench.

Buffer Strip/Special Inlet. A grass filter strip a minimum of 6-m (20 ft) wide should surround the trench on all sides over which surface flow reaches the trench. A special inlet can be used to prevent floatable material, solids, grease, and oil from entering trenches that are located below ground (Young et al, 1996).

Filter Fabric. The bottom and sides of the trench will be lined with filter fabric soon after the trench is excavated. The fabric will be flush with the sides, overlap on the order of 0.6 m (2 ft) over the seams, and not have trapped air pockets. As an alternative, 150 mm (6 in) of clean, washed sand may be placed on the bottom of the trench instead of filter fabric (Young et al, 1996).

Grass Cover. If the trench is grass covered, at least 0.3 m (1 ft) of soil will be over the trench for grass substrate (Young et al, 1996).

Surface Area. The surface area of the trench can be engineered to the site with the understanding that a larger surface area at the bottom of the trench increases infiltration rates and helps to reduce clogging. The depth may be limited by seasonal groundwater levels (Young et al, 1996).

Surface Area of the Trench Bottom. Constituent removal in a trench can be improved by increasing the surface area of the trench bottom. This can be done by adjusting the geometry of the trench to make it shallow and broad, rather than deep and narrow. Greater bottom surface area increases exfiltration rates and provides more area and depth for soil filtering. In addition, broader trench bottoms reduce the risk of clogging at the soil/filter cloth interface by spreading exfiltration over a wider area (Young et al, 1996).

Avoidance of Compaction. Compaction during construction will be avoided if possible by excavating from the sides of the basin as opposed to from the basin floor. If using equipment on the basin floor is unavoidable, light equipment will be used, and the floor will be deeply tilled with a rotary tiller or disc harrow upon completion of excavation. This should be followed by a pass with a leveling drag (Schueler, 1987). Another useful reference on techniques to avoid compaction is *Fundamentals of Urban Runoff Management: Technical and Institutional Issues,* Richard Horner, et. al.

Groundwater Table. The groundwater table should be at least 0.6 to 1.2 m (2 to 4 ft) below the bottom of the trench (Young et al, 1996).

Distance from Wells and foundations. The trench will be at least 30 m (100 ft) away from any drinking water supply well, and at least 3 m (10 ft) down-gradient and 30 m (100 ft) up-gradient from building foundations (Schueler, 1987).

Drain Time. The drain time will be between two and three days. The total volume of the trench should drain in 72 hours (if greater than the water quality volume), while the calculated water quality volume should drain in 48 hours (Young et al, 1996).

Backfill Material. The backfill material in the trench will be D_{50} sized between 40 and 80 mm (1.5 and 3 in) and the clay content will be limited to less than 30 percent. The porosity of the material should be between 0.3 and 0.4 (Young et al, 1996).

Observation Well. An observation well of 100-mm to 150-mm (4-in to 6-in) diameter PVC will be located in the center of the trench and the bottom will rest on a plate. The top should be capped (Young et al, 1996).

Overflow Berm. A 50-mm to 75-mm (2-in to 3-in) emergency overflow berm on the downstream side of the trench serves a twofold purpose. First, it detains surface runoff and allows it to pond and infiltrate to the trench. The berm also promotes uniform sheet flow for runoff overflow (Young et al, 1996).

Slope. Surface trenches are not recommended when contributing slopes are greater than five percent. The slope of the bottom of the trench will be near zero to evenly distribute exfiltration, unless the design includes a positive outlet (Young et al, 1996).

2.3.3 Maintenance

The infiltration trench will be monitored via the observation well to ensure that acceptable permeability is maintained over the life of the project. The trench must be completely drained within 72 hours. Maintenance of the trench would entail removal of the gravel matrix and the filter fabric, and replacement of these components.

2.3.4 Water Quality Monitoring

Water quality samples will be collected from the vadose zone below the trenches. This type of sampling requires a pressure-vacuum lysimeter. The lysimeter will be installed according to the manufacturer’s recommendations and placed so that samples are collected at a depth of 1-2 m (3-6 ft) below the trench floor. This type of sampling is only appropriate for the analysis of dissolved constituents, because the water must be drawn through a ceramic or Teflon cup.

Collection of sufficient sample volumes from the unsaturated zone is normally only possible following significant rainfall. Groundwater quality changes relatively slowly in response to changes in the characteristics of the recharged water, so an intensive monitoring program is not necessary. Samples will be collected twice each year, in December and February. Based on previous water quality monitoring of runoff from highways in the Los Angeles area, the main dissolved constituents of concern are heavy metals. Therefore, the samples will be analyzed for the zinc, lead and copper.

The trenches will be visually monitored for two years to determine the following:

- Trench surface stabilization methods to promote infiltration,
- Rates of infiltration under typical stormwater runoff conditions,
- Operation and maintenance requirements, and
- Tendency for clogging.

A monitoring well will be constructed in each of the infiltration trenches to monitor the rate of infiltration into the soil and to determine whether the trenches are draining in the recommended time. Measurements of water level in the monitoring well will be made twice a year following rainfall events of at least 12 mm (0.5 inches). This data will indicate the rate of infiltration under typical conditions and assess how that rate changes during the monitoring period.

Project personnel will observe the performance of the infiltration trenches during four storms each year. Logs will be kept to indicate the degree to which clogging of the trench surface is restricting the flow of runoff into the trench.

2.3.5 Schedule/Cost

Following is a list of milestone dates (target schedule) for the Infiltration Trench Pilot Project:

1. Site Selection Complete: 1/9/98
2. Design Complete: 5/15/98
3. Project Bid Complete: 8/1/98
4. Construction Complete: 12/1/98
5. Monitoring: 12/1/98 through 3/30/00
6. Final Report Complete: 7/2000

The total cost for construction of an infiltration trench is estimated to be $52,000. One infiltration trench will be constructed as a part of the District 11 BMP Retrofit Pilot Program for a total construction cost of $52,000 for this BMP.

2.4 BIOFILTRATION SWALES AND STRIPS

Caltrans will construct biofiltration swales at two sites. A biofiltration strip will be constructed at one site. There are two key elements to investigate related to the use of vegetative controls for treating highway runoff in this area. The first is the identification of appropriate vegetation for an area with little rainfall and prolonged dry spells. The second is the evaluation of the constituent removal, which will be associated with the selected vegetation.

Caltrans will identify a suitable seed mix for use in the filter strips and swales. Criteria used for the selection of the mix will include: 1) vegetation stays below a maximum height of six inches to avoid mandatory mowing; 2) vegetation is drought tolerant and does not require irrigation; 3) vegetation is compatible with adjacent landscape and Caltrans policy relative to Integrated Vegetation Management (IVM) principles; and 4) vegetation is suitable for a BMP type application (e.g., provide adequate 'filtering' of runoff). Relevant available information on the environmental requirements of the potential vegetation selections will be reviewed and considered to make choices and develop planting and maintenance plans best suited for conditions at the study sites.

The biofiltration strip will be constructed in conjunction with an infiltration trench to provide pretreatment, utilizing a 'treatment train' approach. The constituent removal performance of the biofiltration strip will be determined independently of the associated infiltration trench.

2.4.1 Site Selection (Young et al, 1996)

Swales

The suitability of a swale at a site will depend on land use, size of the area serviced, soil type, slope, imperviousness of the contributing watershed, and dimensions and slope of the swale system. (Schueler, 1992). In general, swales can be used to serve small areas, less than 4 ha (10 ac) in size, with slopes no greater than 5 percent. The seasonal high water table should be at least 0.3 to 0.6 m (1 to 2 ft) below the surface and buildings should be at least 3 m (10 feet) from the site. Use of natural topographic lows is encouraged, and natural drainage courses should be regarded as significant local resources to be kept in use.

Drainage patterns and contributing areas can be determined from contour maps generated from surveys. Roadside ditches should be regarded as potential sites as well. The suitability of swales may be reduced as the number of culverts increase, and they are generally not compatible with extensive sidewalk systems.

Swale systems require dry soils with good drainage and high infiltration rates for better constituent removal (Yousef, et al., 1985). It is desirable for the permeability or final infiltration rate of the underlying soil to be at least 4.3 mm/h (0.17 in/h). The suitable textural classes of the soil underlying the swale are sand, loamy sand, sandy loam, loam, silt loam, and sandy clay loam. Heavy clays that would not support good vegetation and would promote ponding should be avoided. Soil types in the area will be determined through soil survey maps.

The area required for a swale system varies, depending on area to be served, soil types, and design. A length of 61 m (200 ft) is often recommended, although some swale designs have been effective with lengths between 30 and 38 m (100 to 125 ft). Width varies from 0.6 to 2.4 m (2 to 8 ft), and can be adjusted to a maximum of 3.1 m (10 ft) to increase the area of the swale system where an acceptable length cannot be achieved (Washington State Department of Transportation, 1995).

The topography of the site should permit the design of a channel with a slope and cross-sectional area sufficient to maintain an appropriate flow velocity. Site topography may also dictate a need for additional structural controls. Recommendations for longitudinal slopes range between 2 and 6 percent (Khan, 1993). Shallower slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity and decrease detention time, and may require energy dissipating and grade check. Steep slopes can also be managed through the use of a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes additional infiltration.

The identified swale sites are located along I-5 (southbound) at Palomar Airport Road and on SR 78 (eastbound) at Melrose Place. Further information relative to the sites is referenced to a report entitled, *Composite Siting Study, District 11*, dated February 1998, prepared by Robert Bein, William Frost and Associates.

Filter Strips

The most important criteria for selection and use of this BMP for highways are soils, space, and slope, where:

Soils and moisture are adequate to grow relatively dense vegetative stands. Underlying soils should be similar to that required for swales so that much of the runoff will be infiltrated. The presence of clay and organic matter in soils improves the ability of filter strips to remove constituents from the surface runoff (Schueler, 1992).

Sufficient space is available. Because filter strip effectiveness depends on having an evenly distributed sheet flow, the size of the contributing area and the associated volume runoff have to be limited (Urbonas, 1992). To prevent concentrated flows from forming, it is advisable to have each filter strip adjacent to the highway pavement so that they are subjected only to low flow rates.

Slope. When filter strips are used on steep or unstable slopes, the formation of rills and gullies can disrupt sheet flow (Urbonas, 1992). As a result filter strips will not function at all on slopes greater than 15 percent and may have reduced effectiveness on slopes between 6 and 15 percent. Simple V-shaped highway medians or shoulder areas with length of at least 8 meters (27 feet), full vegetative cover, and slopes less than 12% are effective at reducing concentrations of many highway stormwater constituents.

The selected biofiltration site is located at the Carlsbad Maintenance Station.

2.4.2 Design Guidance

Swales

Several criteria should be kept in mind relative to swale design. These provisions presented in Table 2 have been developed through a series of studies conducted on swale performance. A typical swale cross-section is shown in **FIGURE 4**.

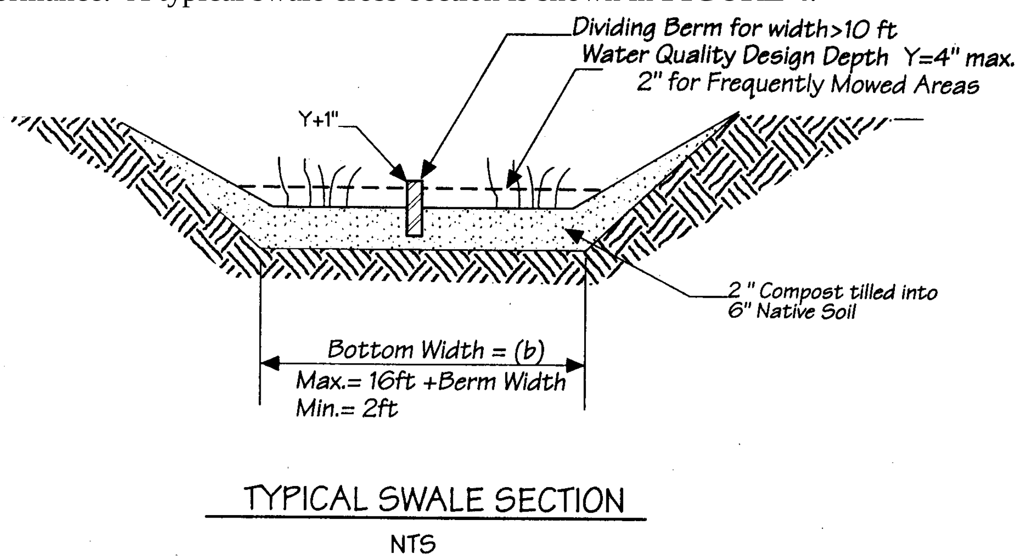

Figure 4 Schematic Of A Typical Swale

Table 2: Criteria for Swale Design (Young et al, 1996)

Parameter	Optimal Criteria	Minimum Criteria
Hydraulic Residence Time	9 min	> 5 min
Average Velocity	< 0.27 m/s (0.9 ft/s)	-
Width	2.4 m (8 feet)	0.6 m (2 feet)
Slope	2 – 6%	1 %
Side Slope	4:1	2:1

The maximum flow velocity in the swale under drainage design conditions (25-year event) shall be limited to 1.2 m/s (4 ft/s), consistent with the Caltrans Highway Design Manual. Velocities for the water quality storm event will be much lower, due to the lower discharge.

There are a number of ways to apply the design procedure, depending on the order in which the steps are performed and the variables established at the beginning of the process. The procedures described below were set forth by Horner in *Biofiltration for Stormwater Runoff Quality Control*, published in 1993. Horner's procedure reverses Chow's order, designing first for capacity, to emphasize the promotion of biofiltration, rather than the simple conveyance of stormwater. The following steps are recommended to be conducted in order to complete a swale design:

(1) Determine peak flow rate to the system (water quality and drainage design storm).
(2) Determine the slope of the system (from site geometry).
(3) Select a swale shape (skip if filter strip design).
(4) Determine required channel width (based on hydraulic requirements).
(5) Calculate the cross-sectional area of flow for the channel.
(6) Calculate the velocity of channel flow.
(7) Calculate swale length (based on site geometry).
(8) Select swale location based on the design parameters.
(9) Select vegetation cover for the swale.
(10) Check for swale stability.

Filter Strips

1. Filter strips are effective with slopes of up to 12 percent. Filter strips with greater slopes may not reliably treat runoff from highways; therefore, the maximum recommended slope for vegetated buffer strips is 12% (Barrett et al, 1997).

2. The minimum recommended length of a filter strip when used to treat highway runoff is 8 meters (27 feet), if the slope of the strip is less than 12% and there is full vegetative cover (Barrett et al, 1997).

3. The area to be used for the strip will be free of gullies or rills that can concentrate overland flow (Schueler, 1987).

4. The top edge of the filter strip along the pavement will be designed to avoid the situation where runoff would travel along the top of the filter strip, rather than through it. Berms may be placed at 15 to 30 m (50 to 100 ft) intervals perpendicular to the top edge of the strip to prevent runoff from bypassing it (Washington State Department of Transportation, 1995).

5. The top edge of the filter strip will be level, otherwise runoff will tend to form a channel in the low spot.

6. Filter strips will be landscaped after other portions of the project are completed (Washington State Department of Transportation, 1995).

A schematic of a combination filter strip and grassy swale is shown in Figure 5.

2.4.3 Maintenance

Biofilters require maintenance of the vegetation including limiting the height of the growth to about 6 inches and ensuring good coverage. Standing water must be eliminated through regrading or sediment removal and debris must be removed from the surface areas. Any condition that promotes the concentration of flow across a strip-type biofilter must be corrected.

2.4.4 Water Quality Monitoring

The effectiveness of these vegetative controls for reducing the concentrations of various constituents in highway runoff will be evaluated during a monitoring program.

Planting time will be chosen to provide time for vegetation establishment before the beginning of the rainy season. To determine whether climatological, soil and topographical conditions allow for adequate vegetation establishment, the irrigation of the sites during the establishment stage will be specified according to the requirements of the selected vegetation. The sites will be evaluated to determine whether they have sufficient vegetative cover. The degree to which vegetation has become established will be determined by performing a vegetation survey at least every month during the period of October through April and every other month from May through September. An established protocol will be followed to determine the amount and type of vegetative coverage.

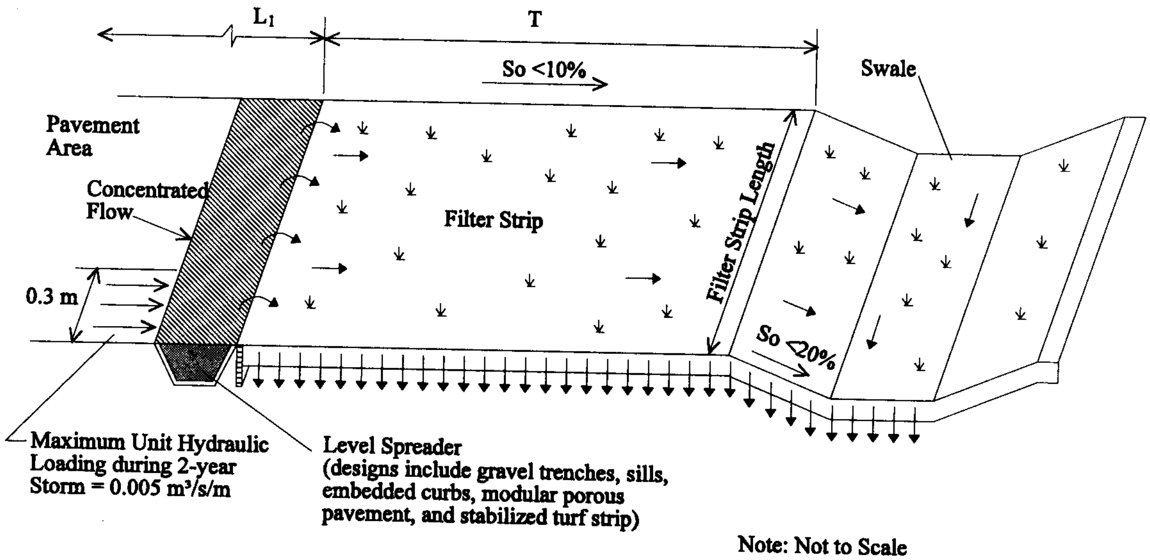

Figure 5 Schematic Of Biofiltration Filter Strip

Constituent removal effectiveness will be determined by comparing the water quality of untreated highway runoff with that discharged from the vegetative control. Highway runoff data will be determined by sampling highway runoff as it leaves the pavement in the vicinity of the experimental sites. A sampling setup similar to that shown in Figure 6 could be used to collect sufficient runoff to sample four times per year.

Flow weighted composite samples will be collected where runoff is discharged from the vegetative controls. These samples will be analyzed for the following constituents::

- total suspended solids (TSS),
- zinc,
- lead,
- copper,
- nitrate nitrogen,
- total Kjedahl nitrogen, and
- total phosphorus.

Manual grab samples will be collected during selected events to determine the instantaneous concentrations of

- total petroleum hydrocarbons, and
- fecal coliform.

Several published studies relate constituent removal effectiveness to hydraulic residence time of runoff in grassy swales. The residence time for the constructed swales will be calculated for the average storm using Manning’s equation, dye tracing, or some other appropriate technique. The relationship between residence time and constituent removal will be established and compared to previous work.

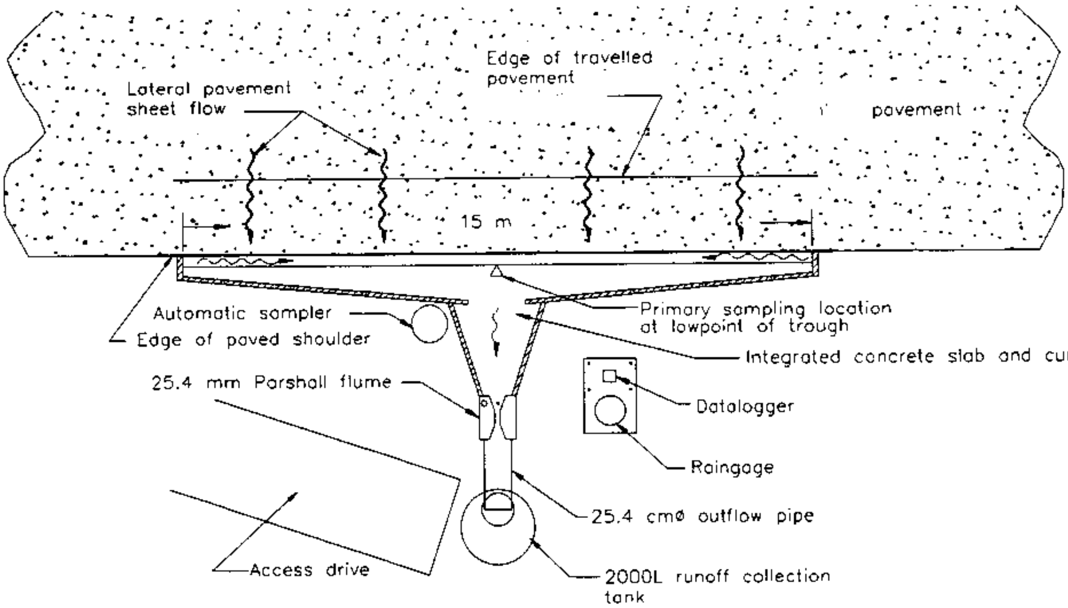

Figure 6 Sampling Design For Swale And Filter Strips (After Sansalone Et Al, 1997)

2.4.5 Schedule/Cost

Following is a list of milestone dates (target schedule) for the Biofiltration Swales and Strips Pilot Project:

1. Site Selection Complete: 1/9/98
2. Design Complete: 5/15/98
3. Project Bid Complete: 8/1/98
4. Construction Complete: 12/1/98
5. Monitoring: 12/1/98 through 3/30/00
6. Final Report Complete: 7/2000

The total cost for construction of a biofiltration swale is $475,000. The total cost for construction of a biofiltration strip is $103,000. Two biofiltration swales, and one biofiltration strip will be constructed as parts of Projects 1 and 2, for a total biofilter construction cost of $253,000.

2.5 MEDIA FILTERS

Caltrans will construct four media filters at maintenance stations and park-and-ride lots. Media filters are defined as chambers containing filtering medium such as sand, compost, or sand/peat layers that discharge to an underdrain system. Both sand and compost media filters will be used in this study.

2.5.1 Site Selection (Young et al, 1996)

Media filter BMPs may provide effective treatment in areas where conventional BMPs fail or cannot be applied at all, including:

Space-Limited Areas	Media filters can be applied in confined urban areas or in any instance where space is limited. Since they can be completely self-contained in underground vaults, a media filter can be placed underneath pavement to maximize land use.
Arid Climates	BMPs such as ponds, wetlands, and vegetative filter strips require relatively moist environments to be effective. No such limitation exists for media filter BMPs, as they can be completely self-contained and can function on an intermittent basis.

While media filters can provide options in areas where the application of more conventional BMPs is limited, there are a number of site considerations that must be recognized in order to maximize the effectiveness of the unit. Aside from needed vertical clearances, the most important consideration is the extent to which runoff from bare soil will be able to enter the filter. The biggest threat to the long-term successful operation of any filter is the introduction of excessive amounts of sediment that cause premature clogging of the filter media. For this reason, it is recommended that media filter BMPs be applied to treat stormwater runoff from relatively small, impervious watersheds (e.g., parking lots, roadways, etc.). It is important to ensure all construction activities up-gradient from the filter have been completed and all areas of erosion stabilized before bringing the filter on-line.

These facilities need enough vertical clearance to operate hydraulically (a minimum of about 3 feet). The elevation difference between the inlet and outlet must include clearance for the depth of the settling chamber, water on top of the filter, the filter media, and the underdrains. If the site plan constraints preclude such clearances, then pumping is needed.

Filters in residential areas can present aesthetic and safety problems. Filters designed with open beds can be the source of objectionable odors and can be unsightly. The concrete walls that comprise the filter structure can present safety hazards. Fences should be included around all such structures to reduce hazards.

The selected sites for sand filters are located at the I-5/SR 78 interchange park and ride, the I-5 and La Costa Boulevard park and ride, and the Escondido Maintenance Station. The compost filter site is located at the Kearny Mesa Maintenance Station. Further information relative to the sites is referenced to a report entitled, *Composite Siting Study, District 11*, dated February 1998, prepared by Robert Bein, William Frost and Associates.

2.5.2 Design Guidance – Sand Filters

There have been several types of sand filter designs for the treatment of stormwater runoff introduced since the original one was developed over ten years ago. Some of the more common designs include the Austin Sand Filter, the D. C. Underground Sand Filter, Alexandria Dry Vault Sand Filter, and the Slotted Curb Delaware Sand Filter.

The Austin design (Figure 7) has open-air filters, a full sedimentation basin, and requires the largest amount of space. It is the best design for treating runoff from larger watersheds and where adequate space is available. The Delaware unit (Figure 8) operates on the curbside edge of paved areas and parking lots. It is available as a precast completely self-contained unit and requires the least area for installation. The choice between these two designs will be made during the design process.

If the Austin sand filter is selected, it will be designed according to the guidelines specified by the City of Austin (1988). The Delaware unit will be designed and installed according to the guidelines described by Young et al (1996).

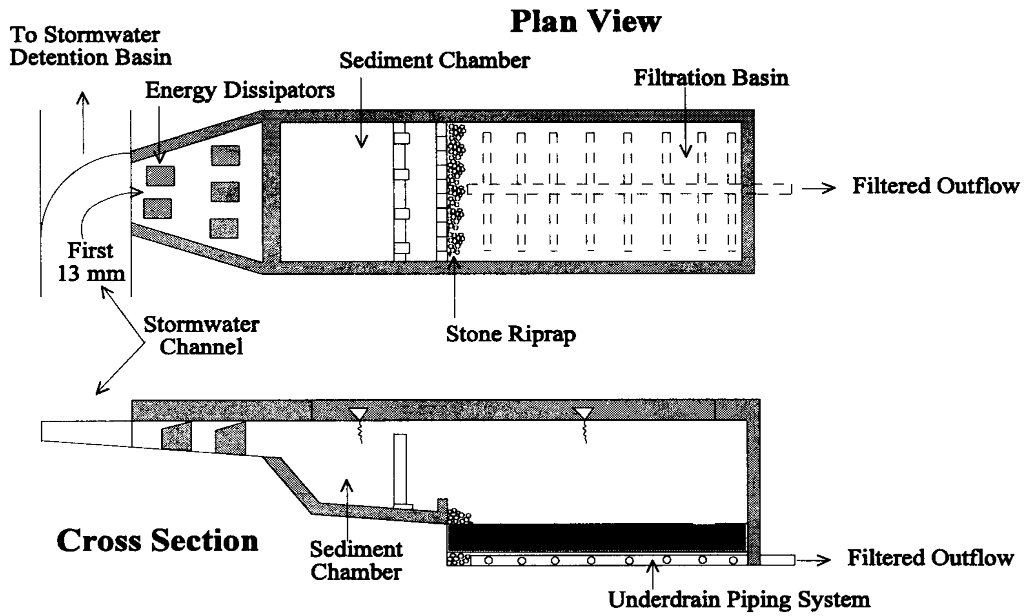

Figure 7 Schematic Of An Austin Sand Filter

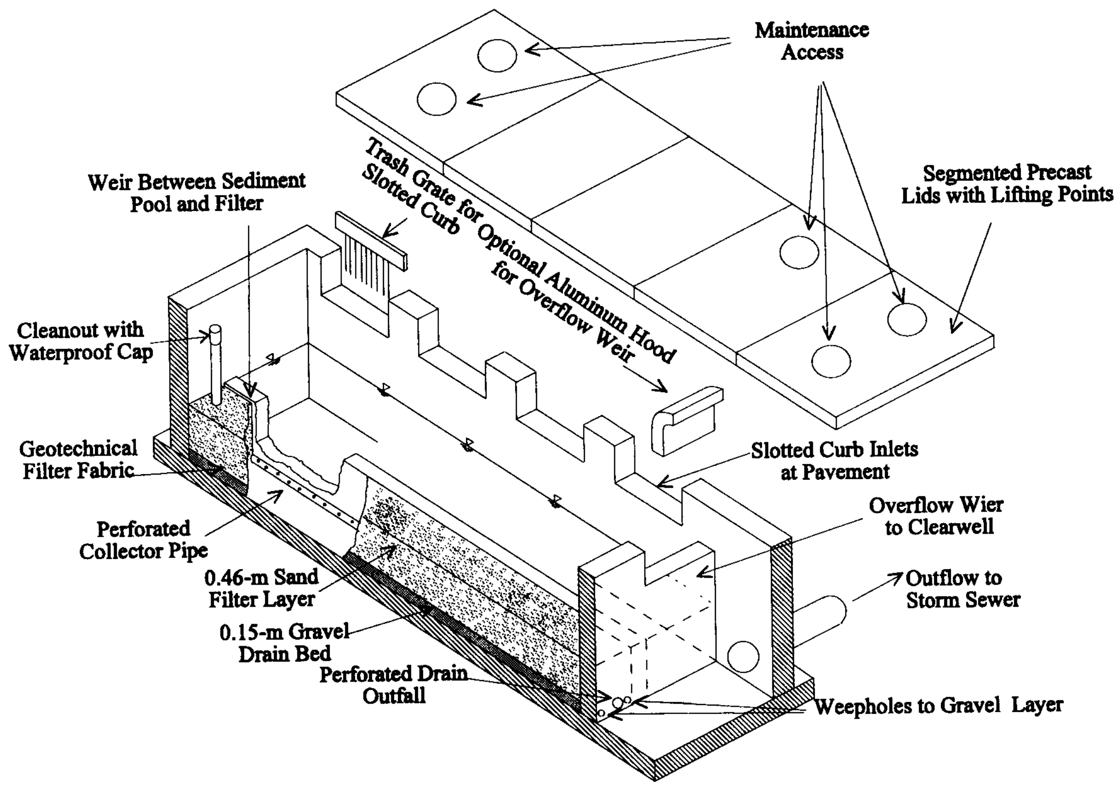

Figure 8 Schematic Of A Delaware Sand Filter

2.5.3 Design Guidance – Compost Filter

The process and apparatus of treating storm water runoff by passing the runoff through a bed of leaf compost material is patented by W & H Pacific, Inc. (Patent Number 5,322,629) and marketed by Stormwater Management (SM) of Portland, Oregon. The leaf compost filter (LCF) removes pollutants through filtration, ion exchange, adsorption, and microbial degradation.

Compost filter sizing is based on a water quality design flow. Since the process and the compost are patented, Stormwater Management will design the leaf compost filter based on the design flow provided and specific site characteristics. An accurate description of land use and potential sediment and pollutant loading sources shall also be provided to SM, who consider these factors in sizing.

Vaults used for the LCF shall conform to the structural requirements specified for catch basins (Caltrans Standard Plans, 1992).

Installation of the leaf compost filter shall follow the manufacturer's recommended procedures. Figure 9 shows a schematic representation of the Leaf Compost Filter.

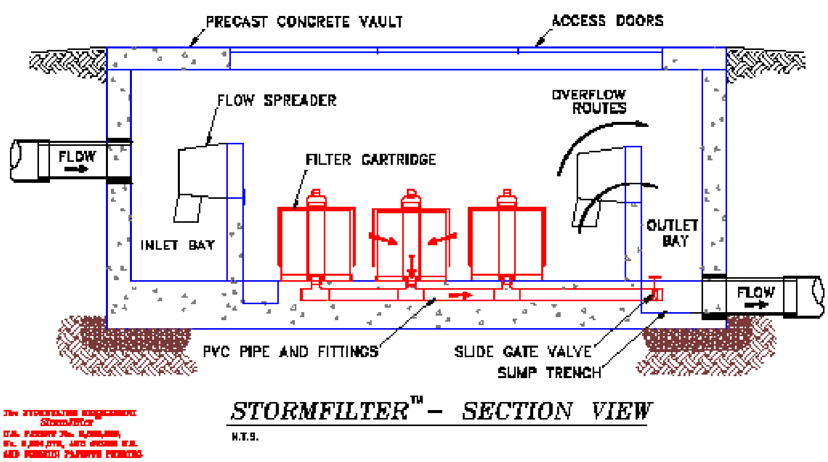

Figure 9 Schematic Design Of Compost Filter

2.5.4 Maintenance

General maintenance practices will include ensuring that the vaults are free from debris that would otherwise block discharge. The filter surface must be maintained to ensure that flow can pass through the media at the design rate. As with infiltration BMPs, a veneer of sediment will accumulate on the media which must be periodically removed.

2.5.5 Water Quality Monitoring

Constituent removal in the media filters will be determined by comparison of the average water quality of runoff entering the facility with that leaving (see Appendix C). Automatic sampling equipment will be installed at the inlet and outlet of the device to collect flow-weighted composite samples. These sites will be designed to incorporate flow measurement structures.

The most appropriate flow measurement structures for filter inlet are Parshall flumes and H flumes. An advantage of these devices is their ability to pass trash and other debris which tend to accumulate in structures such as V-notch weirs. The high velocity through the flume prevents sediment accumulation from runoff with high suspended solids concentrations. In addition, these devices operate with a much smaller head loss than a weir. Depending on the size of the contributing watershed, an H flume is preferred because of its ability to accurately measure a wider range of flows.

Flow measurement at the filter outlet is subject to different constraints than at the inlet. Because of the long detention times, flow rates will necessarily be much lower and most of the trash and debris will have been removed from the runoff. Therefore, a V-notch weir is the preferred option for measuring flow at this location. The type and size will be determined by the size of the watershed and expected discharge rate from the filter.

The runoff samples collected by the automatic sampling equipment will be analyzed for:

- total suspended solids (TSS),
- zinc,
- lead,
- copper,
- nitrate nitrogen,
- total Kjedahl nitrogen, and
- total phosphorus.

Manual grab samples will also be collected during selected storm events to determine the instantaneous concentrations in the treated and untreated runoff for:

- total petroleum hydrocarbons, and
- fecal coliform.

At the end of the monitoring period, samples of the sediment which has been retained by the filter will be collected and analyzed to determine the proper disposal method.

2.5.6 Maintenance

The media filter must be maintained regularly to assure that sediment accumulation does not impede the filtration capacity. Maintenance needs vary from site to site based on the type of land use activity, implementation of source controls, and weather conditions. Leaf compost filters shall be inspected quarterly or at a frequency recommended by Stormwater Management. Inspection and maintenance of media filters shall include:

- The operation and maintenance instructions from the manufacturer shall be kept along with an inspection and maintenance log. The maintenance log shall be available for review.

- Routine maintenance shall include inspection for debris, vegetation, and sediment accumulation, flushing of the underdrain, and compost media removal/replacement.

- Sediment shall be removed when the accumulation causes the infiltration capacity to drop below the design flow rate (instructions are available from the manufacturer for testing infiltration capacity).

- The compost media should be replaced at least once a year or when infiltration capacity is unrecoverable. Sediment removal and/or compost media replacement may require a vactor truck.

- Media shall be disposed of in accordance with applicable regulations. In most cases, the compost media may be disposed of as a solid waste.

2.5.7 Schedule/Cost

Following is a list of milestone dates (target schedule) for the Media Filter Retrofit Pilot Project:

1. Site Selection Complete: 1/9/98
2. Design Complete: 5/15/98
3. Project Bid Complete: 8/1/98
4. Construction Complete: 12/1/98
5. Monitoring: 12/1/98 through 3/30/00
6. Final Report Complete: 1/01

The estimated construction cost for a sand media filter is $150,000. The estimated construction cost for a compost media filter is $200,000. Three sand media filters and one compost media filter will be constructed as Project 5, for a total media filter construction cost of $645,000.

2.6 WET BASIN

A wet basin is a facility that removes sediment, BOD, organic nutrients, and particulate trace metals from stormwater runoff. is accomplished by slowing stormwater using an in-line permanent pool or basin allowing settling of constituents. The wet basin is similar to a dry basin, except that a permanent volume of water is incorporated into the design. Biological processes occurring in the permanent basin pool aid in reducing the amount of soluble nutrients present in the water, such as nitrate and ortho-phosphorus (Schueler, 1987). Because they are designed with permanent pools, wet basins can also have recreational and aesthetic benefits. Concerns associated with this type of BMP include the potential for the device to become a regulated wetland, and potential problems associated with mosquito and vector control.

The term ‘wet basin’ is fairly broad and encompasses wet ponds, constructed wetlands, among other configurations. The type of basin and design details for the pilot installation will be defined in the design phase of the project.

2.6.1 Site Selection

Wet basins may be feasible for highways in residential or commercial areas with a combined drainage area greater than 8 ha (20 ac), possessing a large fraction of off-site drainage and a dependable water source. They would typically not be used in drainage areas less than 4 ha (10 ac) (Schueler, 1987). The area necessary to construct a wet basin is usually between 1 and 3 percent of the contributing drainage area (Urbonas, et al., 1992). They can also be used to capture runoff from parking lots, rest areas, and weigh stations. An adequate source of water must be available to ensure a permanent pool throughout the entire year. If the wet basin is not properly maintained or the basin becomes stagnant, floating debris, scum, algal blooms, unpleasant odors, and/or insects may appear.

In a highway context, wet basins would typically be associated with a site having significant off-site drainage to consider and with a site having year round base flow. Sites that are smaller, have predominantly right-of-way drainage, and no base flow would be served by an extended dry basin or other device.

Soil conditions are important for the proper functioning of wet basins. The basin is a permanent pool, and thus must be constructed such that the water must not be allowed to exfiltrate from the permanent portion of the pool. It is difficult to form a pool in soils with high exfiltration rates soon after construction. Eventually, however, deposition of silt at the bottom of the basin will help slow exfiltration. If extremely permeable soils exist at the site (type A or B), a geotextile or clay liner any be necessary.

The site selected for wet basin is located on I-5 (southbound) at Manchester Avenue. Further information relative to the sites is referenced to a report entitled, *Composite Siting Study, District 11,* dated February 1998, prepared by Robert Bein, William Frost and Associates.

2.6.2 Design Guidelines

The exact nature of the wet basin will be specified during the design phase of the process. Therefore, the design guidelines below will be tailored more specifically to the type of wet basin chosen for each site.

Volume. A variety of methods have been suggested for determining the volume of wet basins (Washington State Department of Transportation, 1995; Urbonas et al.; 1992; EPA, 1986). The recommended size for the facility in Caltrans District 11 will be based on the design storm approach. The water quality volume will be equal to the 1-year 24-hour storm event (i.e., 2.54 cm (1 in) of runoff from the contributing watershed). The volume of the permanent pool will be equal to the water quality volume. This is similar to the design methodology adopted by the Washington Department of Transportation (1995) except that the water volume is twice as large as that required by WSDOT due to the higher intensity storms occurring in southern California.

Basin Shape. The wet basin will be divided into two cells. The first cell (forebay) should be 3-feet deep in order to effectively trap coarser sediments and reduce turbulence, which can resuspend sediments. It should be easily accessible for maintenance purposes. The forebay should be 25% of the total volume of the primary basin (King County Surface Water Design Manual, 1996). The berm dividing the pond into cells shall have a 5-foot (1.5-m) minimum top width, a top elevation set 1 foot lower than the design water surface, maximum 3:1 side slopes. The basin should be long and narrow and generally shaped such that it discourages short-circuiting. A length to width ratio of 3:1 will help minimize short circuiting (Camp, Dresser and McKee, 1993; Schueler, 1987).

Depth. The depth of the basin is important for basin design. If the basin is too shallow, sediment will be easily re-suspended as a result of wind. If the basin is too deep, stratification may occur, possibly causing anoxic conditions near the bottom of the basin. If the basin becomes anoxic, pollutants adsorbed to the bottom sediments may be released back to the water column. The average depth in the main part of the basin should be 1 to 2 m (3 to 6 ft), and depths of more than 2.4 m (8 ft) should be avoided (Schueler, 1987).

Vegetation. The basin surface area to depth relationship shall be such that 30 percent of the basin area has a depth of less than 2 feet (600 mm). This shallow area should follow the perimeter of the basin and be planted with emergent vegetation (10). Planting vegetation around the perimeter of the basin can have several advantages. Vegetation reduces erosion on both the side slopes and the shallow littoral areas. Vegetation located near the inlet to the basin can help trap sediments; algae growing on these plants can also filter soluble nutrients in the water column. Thicker, higher vegetation can also help hide any debris that may collect near the shoreline. Native turf-forming grasses or irrigated turf should be planted on sloped areas, and aquatic species should be planted on the littoral areas (Urbonas et al., 1992). Vegetation can benefit wildlife and waterfowl by providing food and cover at the marsh fringe. A shallow, organic-rich marsh fringe provides an area which enables bacteria and other microorganisms to reduce organic matter and nutrients (Schueler, 1987). It should be noted that this type of vegetation may not be compatible with mosquito control requirements. These issues will be addressed as a part of the further development of the operation and maintenance procedures.

Side Slopes. Gradual side slopes of a wet basin enhance safety, help prevent erosion, and make it easier to establish dense vegetation. It has been recommended that side slopes be no greater than 3:1. If slopes are greater than this, riprap may be used to stabilize the banks (Schueler, 1987). Other sources recommend slopes no steeper than 4:1 above the permanent pool, with side slopes a maximum of 3:1 below the permanent pool, and a littoral zone as mild as 20:1 (Urbonas et al., 1992).

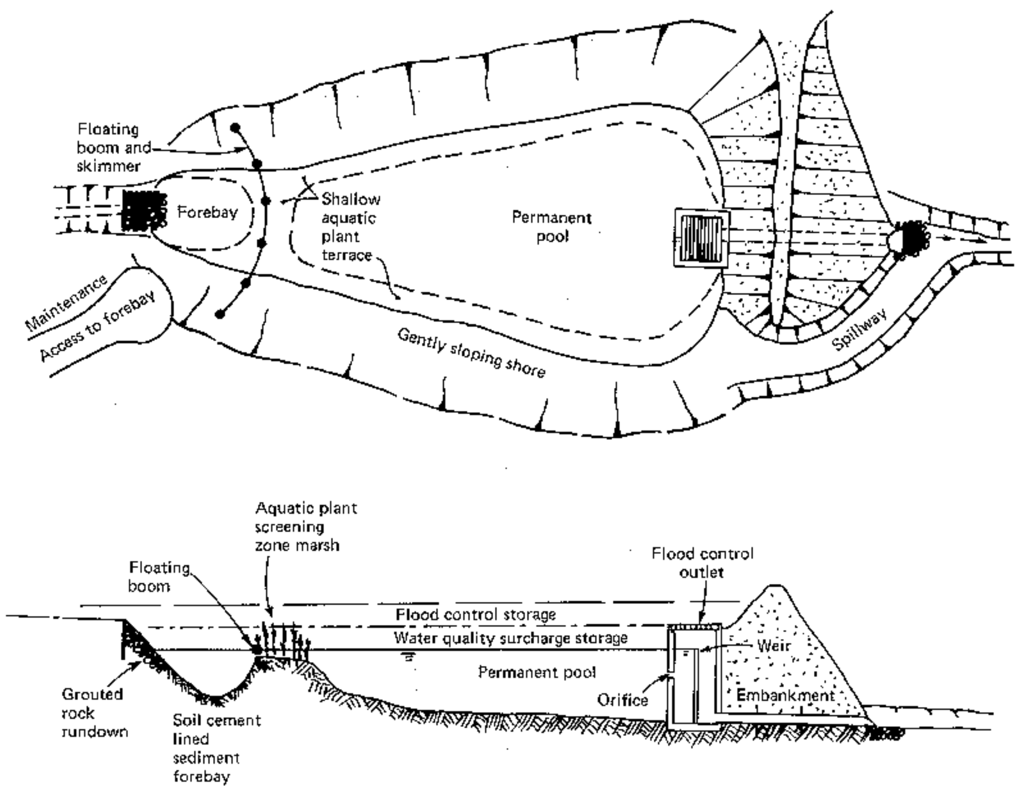

Figure 10 Schematic Design Of A Wet Basin (Urbonas And STAHRE, 1993)

Hydraulic Devices. An outlet device, typically a riser-pipe barrel system, should be designed to release runoff in excess of the water quality volume and to control storm peaks. The outlet device should still function properly when partial clogging occurs. The outlet design should incorporate a drain and valve so that the basin can be drained completely.

Inlet and Outlet Protection. The inlet pipe should discharge at or below the water surface of the permanent pool. If it is above the pool, an outlet energy dissipater will protect the banks and side slopes of the basin from erosion. The stream channel just downstream of the basin outlet should be protected from scouring by placing riprap along the channel. In addition, the slope of the outlet channel should be close to 0.5 percent. Riprap between 460 and 760 mm (18 and 30 in) should be used. If the outlet pipe is less than 610 mm (24 in), 230 to 300 mm (9 to 12 in) riprap may be used. Stilling basins may also be installed to reduce flow velocities at the outfall (Schueler, 1987).

Forebay. A forebay will be installed as part of the wet basin to capture sand and gravel sediment. The forebay should be easily accessible for sediment dredging, and access to the forebay for equipment should be provided.

Emptying Time. A 12- to 48-h emptying time may be used for the water quality volume above the permanent pool (Urbonas, et al., 1992).

Freeboard. The basin embankment should have at least 0.3 m (1 ft) of freeboard above the emergency spillway crest elevation (Schueler, 1987).

Safety: Safety is a major consideration when planning wet basins. Basins will be located where failure would not cause loss of life or property damage. District 11 Composite Siting Study (RBF, 1998) describes specific safety criteria used during site selection process. The size of the basins will be kept below the threshold that would require approval from the State Division of Safety of Dams, which is less than 50 acre-feet of storage and a 25 foot embankment height, or unlimited storage and a maximum 6 foot embankment height.

2.6.3 Maintenance

A clear requirement for wet basins is that a firm institutional commitment be made to carry out both routine and non-routine maintenance tasks. The nature of maintenance requirements for wet basins is outlined below, along with design tips that can help to reduce the maintenance burden.

Inspections. Wet basins need to be inspected on a monthly basis to ensure that the structure operates in the manner originally intended. When possible, inspections should be conducted during wet weather. The embankment should be checked for subsidence, erosion, leakage, cracking, and tree growth. The condition of the emergency spillway should be checked. The inlet, barrel, and outlet should be inspected for clogging. The adequacy of upstream and downstream channel erosion protection measures should be checked. Stability of the side slopes should be checked. Modifications to the basin structure and contributing watershed should be evaluated. The inspections should be carried out with as-built basin plans.

Debris and Litter Removal. As part of periodic mowing operations, debris and litter should be removed from the surface of the basin. Particular attention should be paid to floatable debris around the riser, and the outlet should be checked for possible clogging.

Nuisance Control. Most public agencies surveyed indicate that control of insects, weeds, odors, and/or algae may be needed in some basins. A specialist in mosquito and vector control will be retained to review conditions in the basin and develop an appropriate maintenance procedure to minimize potential problems.

Sediment Removal. Wet basins will eventually accumulate enough sediment to significantly reduce storage capacity of the permanent pool. As might be expected, the accumulated sediment can reduce both the appearance and pollutant removal performance of the basin. The best available estimate is that approximately one percent of the storage volume capacity associated with the two-year design storm can be lost annually. Smaller, stabilized watersheds accumulate sediment at lower rates, while larger watersheds with unprotected channels or ongoing construction fill in more rapidly. The sediment which accumulates at the bottom of the basin should be removed every 5 to 10 years. Testing may be necessary to determine if the sediment contains hazardous materials, using the TCLP protocols. Negative results may cause disposal difficulties. Florida sediments have proven to be non-toxic, as have sediments in Northern Virginia.

Harvesting. If vegetation is present on the fringes or in the basin, it will be harvested annually and the clippings removed to provide export of nutrients and to prevent the basin from filling with decaying organic matter.

2.6.4 Water Quality Monitoring

Constituent removal in the extended detention basin will be determined by comparison of the average water quality of runoff entering the facility with that leaving (see Appendix C). Automatic sampling equipment will be installed at the inlet and outlet of the device to collect flow-weighted composite samples. These sites will be designed to incorporate flow measurement structures.

The most appropriate flow measurement structures for basin inlets are Parshall flumes and H flumes. An advantage of these devices is their ability to pass trash and other debris, which tend to accumulate in structures such as V-notch weirs. The high velocity through the flume prevents sediment accumulation from runoff with high suspended solids concentrations. In addition, these devices operate with a much smaller head loss than a weir. Depending on the size of the contributing watershed, an H flume is preferred because of its ability to accurately measure a wider range of flows.

Flow measurement at the basin outlet is subject to different constraints than at the inlet. Because of the long detention times, flow rates will necessarily be much lower and most of the trash and debris will have been removed from the runoff. Therefore, a V-notch weir is the preferred option for measuring flow at this location. The type and size will be determined by the size of the watershed and expected discharge rate from the basin.

The runoff samples collected by the automatic sampling equipment will be analyzed for:

- total suspended solids (TSS),
- zinc,
- lead,
- copper,
- nitrate nitrogen,
- total Kjedahl nitrogen, and
- total phosphorus

Manual grab samples will also be collected during selected storm events to determine the instantaneous concentrations of:

- total petroleum hydrocarbons and
- bacteria.

At the end of the monitoring period, samples of the sediment that has been retained by the basin will be collected and analyzed to determine the proper disposal method.

2.6.5 Schedule/Cost

Following is a list of milestone dates (target schedule) for the Wet Basin Pilot Project:

1. Site Selection Complete: 1/9/98
2. Design Complete: 5/5/98
3. Project Bid Complete: 8/13/98
4. Construction Complete: 11/30/98
5. Monitoring: 12/1/98 through 3/30/00
6. Final Report Complete: 1/01

The estimated construction cost for a wet basin is $352,000. One wet basin will be constructed as project 4, for a total wet basin construction cost for this program of

$352,000.

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APPENDIX A: SITE SELECTION CRITERIA

REPRESENTATIVENESS

Types of sampling sites specified by Caltrans may include highway sites (freeways, expressways and/or conventional highways), maintenance yards, park-and-ride lots, border check points and weigh stations. It is important to select specific monitoring sites that are representative of typical Caltrans operations for these site types. The following discussions provide guidance on site characteristics to consider when selecting representative monitoring sites.

Highway Sites

Several criteria must be used in the selection of appropriate highway stormwater sampling sites, including traffic volume, grade, and location relative to other land uses. Although certain monitoring areas may appear favorable according to these factors, the following considerations will help to ensure selection of sites that are representative of highway runoff:

Traffic Volume

The selected sampling site should be located where the traffic volume is comparable to the average range of daily traffic volumes in Caltrans District 11 for the type of highway being studied. Selecting sites with typical traffic volumes may help ensure that the sites are representative of normal conditions.

Uniform Flow

Sampling sites should be located where stormwater flows are relatively well mixed, yet tend to be relatively “stable” or “uniform.” To better approach uniform flows, avoid steep slopes (i.e., select sites with pipe slope less than 2% to achieve uniform flows in the subcritical range), junctions, grade changes, and areas of irregular channel shape due to breaks, repairs, roots, debris, etc. Sites should be located where the channel or storm drain is soundly constructed.

Erosion Potential

Avoid areas where the potential for erosion is high, such as areas where land has recently been disturbed by construction or other activities, areas with excessively steep slopes, or cut and fill areas where the land surface has not been fully stabilized.

Surrounding Land Uses

Select sites that are not influenced by surrounding land uses (e.g., atmospheric deposition or flows from non-Caltrans areas). For example, do not select sites in close proximity to agricultural fields that may be sprayed with pesticides, industrial sites that may contribute airborne constituents, or residential areas.

Backwater or Tidal influences

Select sampling sites where the runoff will be free flowing (gravity flow). Avoid areas likely to be affected by backwater and tidal conditions, as these factors can complicate the reliable measurement of flow and the interpretation of data.

High Groundwater Table

A high groundwater table may influence stormwater runoff if groundwater reaches the surface and mixes with stormwater runoff; therefore, avoid sites where there is a potential for this to occur.

Illegal Discharges/Illicit Connections

An inspection of the site should include identification of any signs of illegal discharges, which generally include illegal discharge/dumping of wastes (e.g., used oil and other automotive fluids, trash and debris, etc.) and illicit connections (e.g. sanitary sewer lines) to the storm drainage system. Selected sites should be free of illegal discharges and illicit connections.

To adequately assess illegal discharges and illicit connections, sites should be visited during dry weather to observe any non-stormwater discharge. The following on-site observations should be made to identify illegal discharges and illicit connections:

> Presence of debris, or rubbish piles on roadway shoulders, at turnouts, in open channels or other areas of the potential monitoring site. Solid waste dumping often occurs on roadways with light traffic loads or in areas not easily visible from the traveled way. Approach containers, such as bottles or barrels, with caution as they may contain hazardous liquids or solids.
>
> Visible signs of staining or unusual colors to the pavement or surrounding adjacent soils.
>
> Pungent odors coming from the drainage system.

Discoloration or oily substances in the water or stains and residues on ditches, channels or drain boxes.

Flow during dry weather.

Unusual flows in subdrain systems used for dewatering.

Excessive sediment deposits, particularly adjacent or near active off-site construction projects.

All observations should be documented for potential future use. If an illegal discharge or illicit connection is observed on a Caltrans right-of-way, the Caltrans Stormwater Coordinator will be notified. If the nature of an observed discharge is unknown or suspected of being a hazardous substance, no further investigation should be conducted and the incident reported to the Caltrans Stormwater Coordinator.

Significant Transitions

When considering representative highway sampling sites, it is generally desirable to select areas that are unlikely to undergo significant transition in the near future. This is to prevent the intrusion of contaminants from construction activities, or other alterations to the monitored area that may cause changes in the quality of the runoff (i.e., cause the quality of the runoff to be atypical of the site being monitored).

Maintenance Yard

Locations where highway maintenance vehicles and equipment are stored and serviced will be selected as stormwater monitoring sites. Maintenance activities, including vehicle and equipment cleaning, fueling, and repair, may all contribute constituents to stormwater runoff.

Effective monitoring of maintenance yards requires selection of sampling sites that adequately represent typical runoff from the site, prior to mixing with off-site sources. Select sampling sites that have the following characteristics:

Runoff from the facility has combined to form a definable runoff stream of adequate depth to sample.

The runoff stream represents the full range of activities at the facility.

On-site runoff has not combined with runoff from off-site sources.

Adequate grade or a drop-off exists (e.g., into a drain inlet) to enable collection of runoff samples by placing a sample bottle or automatic sampler intake in the runoff stream (if manual sampling is planned).

Park-and-Ride Lots

Monitoring at park-and-ride lots may be included in the Caltrans retrofit pilot study. Effective monitoring of park-and-ride lots requires selection of sampling locations that adequately represent typical runoff from the site prior to mixing with off-site sources. Select sampling sites that have the following characteristics:

Runoff from the area has combined to form a definable runoff stream of adequate depth to sample.

On-site runoff has not combined with runoff from off-site sources.

Illicit connections are not present (refer to highway site section, above).

Trash receptacles are provided and the area is routinely checked for trash and debris (including illegal dumping).

PERSONNEL SAFETY

It is essential to ensure monitoring crew safety from such hazards as traffic, explosive or toxic gases, possible injury due to poor footing in slippery conditions, and hazards posed by poor visibility or other challenging conditions during adverse weather, especially at night.

To help avoid hazards, personnel should be physically capable of performing all tasks required for sample collection and be familiar with the program's Health and Safety Plan. The Health and Safety Plan must be developed prior to the initiation of any sample collection activities and should include information on at least the following: hazard evaluation (e.g. chemical, physical, etc.), contingency plan, personal protective equipment, and emergency information.

SITE ACCESS

Ease of vehicle and personnel access to the monitoring sites for equipment installation and sample collection activities should be assured for the full range of weather conditions that may be encountered. Safe access must be confirmed, especially during wet-weather conditions. For example, ensure that the access point and available parking are at a safe distance from traffic, that any roads to the sampling location are adequate and reliable (e.g., limited potential to be muddy or flooded during wet weather), and that access does not require crossing private property.

For stormwater outfall monitoring sites, access into the drainage line/outfall for the flow measuring and sample collection equipment must be feasible and practical. Where practical, access to monitoring sites and equipment should be possible without confined space apparatus or exposure to fast moving traffic, for ease of servicing.

EQUIPMENT SECURITY

It is necessary to minimize the susceptibility of automated sampling and flow measurement equipment to vandalism or other possible damage. To ensure security, automated monitoring equipment should be installed in a protective enclosure that is lockable and resistant to vandalism and tampering. Sites should be selected that have a flat, accessible area that is large enough for installation of any necessary enclosures, including fencing if necessary.

FLOW MEASUREMENT CAPABILITY

Obtaining accurate flow measurements at monitoring stations is necessary to ensure representativeness of flow-weighted composite samples, to determine constituent mass loadings, and to assess the relationship between rainfall and runoff to support mathematical modeling. The hydraulic characteristics necessary to allow for accurate flow measurement include a relatively straight and uniform length of pipe or channel with no confluences (i.e., wyes or tees in the storm drain lines) or grade changes, and the absence of backwater effects.

Monitoring sites should be selected at locations where flow rate will be adequate under typical storm conditions to provide for both accurate flow measurement and automatic sample collection. This can be checked in advance by roughly calculating the runoff flow depth expected in the pipe during a storm of typical intensity for the study area.

Flow measurement stations should be located sufficiently downstream from inflows to the drainage system to achieve well-mixed conditions across the channel, and to favor the likelihood of "uniform" flow conditions. In the vicinity of a confluence, the flow sensor and sample collection inlet should be placed a minimum of five pipe diameters upstream and ten pipe diameters downstream of any confluence to minimize turbulence and ensure well-mixed flow.

Backwater effects should be avoided especially where sampling protocols make use of depth-based flow measurement. Specifically, backwater effects will result in non-uniform flow conditions, which compromise the ability to measure flow when using depth-based methods. In addition, sampling stations in pipes, culverts, or tunnels should be located to avoid surcharging over the normal range of precipitation expected during monitoring events.

Telephone lines can be used for remote communication with automated equipment. Telephone access provides a convenient mode of rapidly accessing information from field equipment during field activities. Cellular telephones are a possible alternative if telephone lines are not available. However, cellular telephone operations should be thoroughly checked prior to any monitoring activities (e.g., ensure that there is a reliable provider in the area and test reception).

NON-CALTRANS SOURCES

Monitoring sites should be selected such that the monitored stormwater runoff originates solely within Caltrans freeway systems or facilities. Any site whose drainage area includes other land use types (e.g., commercial, residential, agricultural, etc.) should be avoided to eliminate collection of non-Caltrans flows.

SITE EVALUATION

Each potential monitoring site will be visited, to confirm the expected site characteristics and verify whether the site is suitable for the needs of the program. The visit should be conducted preferably during or after a storm, when the discharge can be observed. A wet-weather visit can provide valuable information regarding logistical constraints that may not be readily apparent during dry weather. However, a dry weather visit should also be conducted to observe any illegal discharges.

A list of criteria, specific to the program objectives and including the considerations discussed in this section, will be developed prior to visiting potential sites. These criteria will be used to produce a site visit log form, which will be filled out during each site inspection.

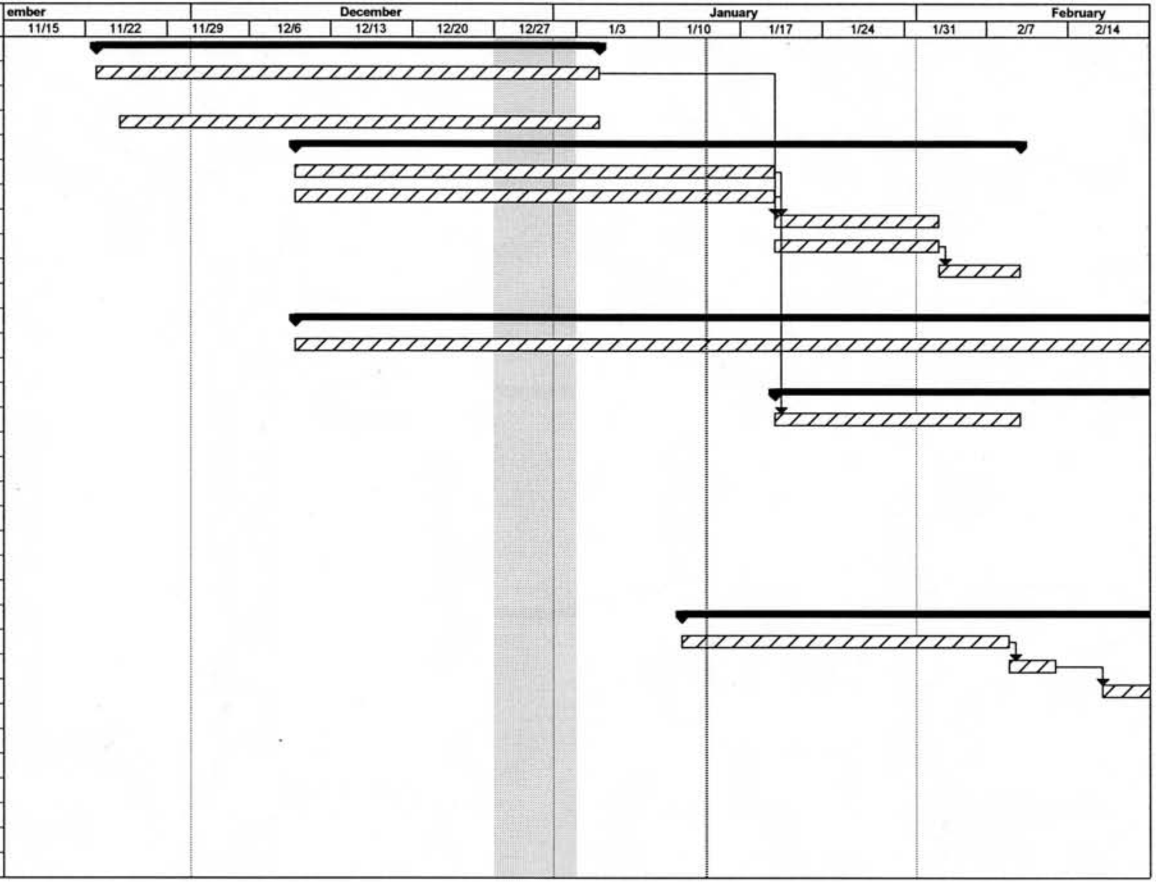
Criteria to be documented during a site visit may include type of site, drainage area characteristics, type of runoff, whether an appropriate sampling location exists, potential safety issues, site access, whether accurate flow measurement is achievable, and if telephone and electrical power are available.

In addition, a check list may be useful to record whether certain conditions exist at a given site, such as: tidal influences, illegal dumping, illicit connections, high groundwater table, erosion, runoff from landscaped areas, adjacent commercial farming, contributing residential runoff, or nearby industrial sites. Once these observations have been made, it is possible to determine if the site is representative and appropriate for the objectives of this project.

APPENDIX B: MASTER SCHEDULE

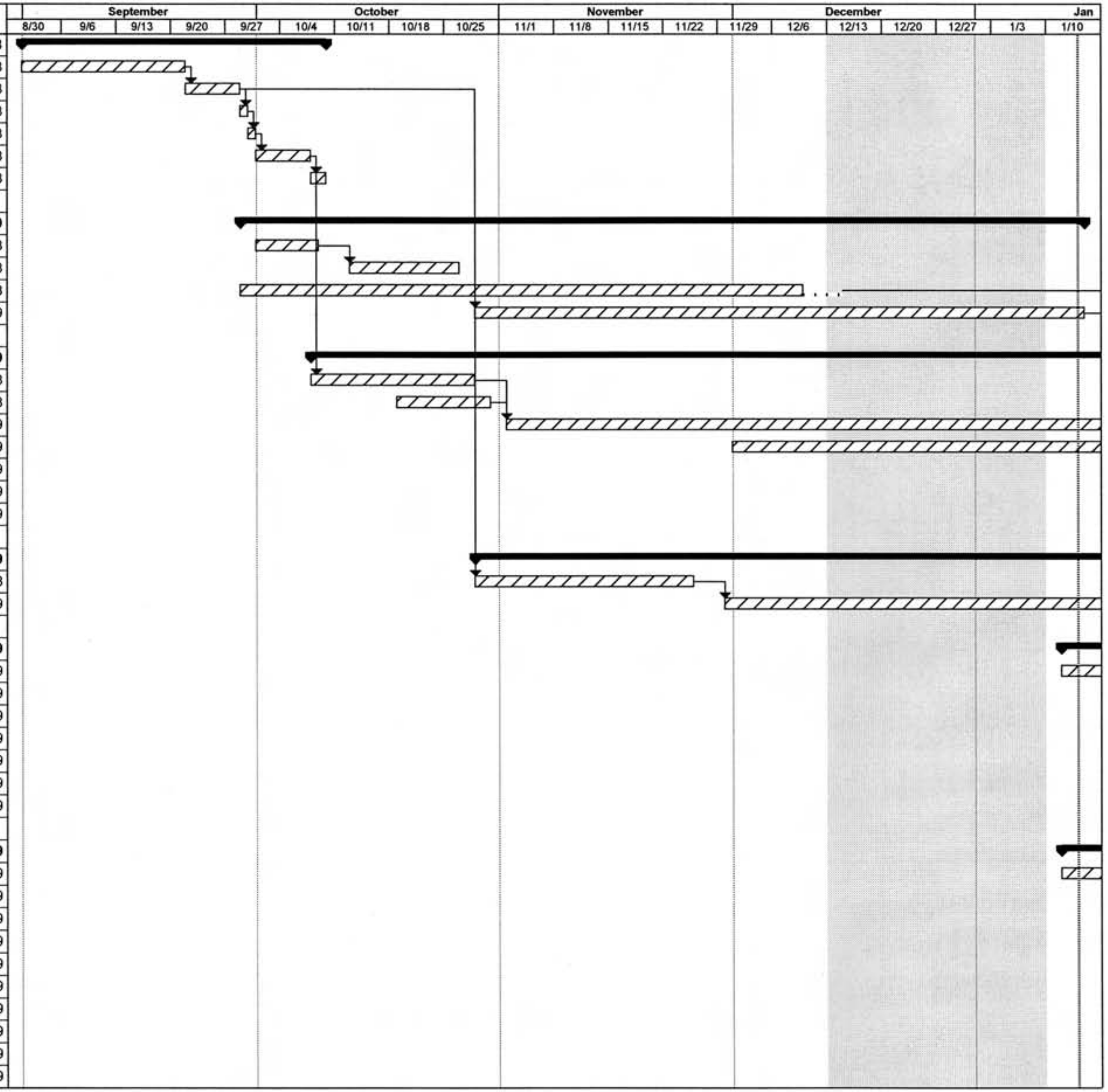
CALTRANS BMP RETROFIT PILOT PROGRAM
CALTRANS DISTRICT 11
MANCHESTER EDB IMPLEMENTATION SCHEDULE

ID	❶	Task Name	Duration	Start	Finish
1		**DESIGN/HYDROLOGY REP0RT**	**22 days**	**11/23/98**	**1/4/99**
2		Prepare Draft Report	4.4 wks	11/23/98	1/4/99
3					
4		Geotech Investigation	20 days	11/25/98	1/4/99
5		**DESIGN**	**36 days**	**12/10/98**	**2/9/99**
6		Draft Design	21 days	12/10/98	1/19/99
7		Draft Specifications	21 days	12/10/98	1/19/99
8		Caltrans/DHS/VCD Review	10 days	1/20/99	2/2/99
9		Plaintiff Review	10 days	1/20/99	2/2/99
10		Finalize Design/Specs	5 days	2/3/99	2/9/99
11					
12		**ENVIRONMENTAL**	**67 days**	**12/10/98**	**3/25/99**
13		Coastal Zone Permit Process	13.4 wks	12/10/98	3/25/99
14					
15		**CONSTRUCTION**	**100 days**	**1/20/99**	**6/10/99**
16		Encroachment Permit	15 days	1/20/99	2/9/99
17		Advertise	1 day	3/1/99	3/1/99
18		Bid	10 days	3/2/99	3/15/99
19		Ct Notice to Proceed	5 days	3/16/99	3/22/99
20		Award	1 day	3/26/99	3/26/99
21		Execute contract	3 days	3/29/99	3/31/99
22		Construction	50 days	4/1/99	6/10/99
23					
24		**OMM PLAN**	**91 days**	**1/12/99**	**5/20/99**
25		Draft Vol I Addendendum (RBF)	19 days	1/12/99	2/8/99
26		Caltrans Review	4 days	2/9/99	2/12/99
27		Final Draft	7 days	2/17/99	2/25/99
28		Plaintiff Review	10 days	2/26/99	3/11/99
29		Finalize Vol I Addendum	5 days	3/12/99	3/18/99
30		Draft Vol II Addendum (KLI)	15 days	3/19/99	4/8/99
31		Caltrans Review	5 days	4/9/99	4/15/99
32		Final Draft Vol II	5 days	4/16/99	4/22/99
33		Plaintiff Review	10 days	4/23/99	5/6/99
34		Final Vol II	10 days	5/7/99	5/20/99



CALTRANS BMP RETROFIT PILOT PROGRAM
CALTRANS DISTRICT 11
WET BASIN IMPLEMENTATION SCHEDULE

ID		Task Name	Duration	Start	Finish
1		**BMP SITING/INVESTIGATION**	**29 days**	**9/1/98**	**10/9/98**
2		Site Selection	15 days	9/1/98	9/21/98
3		Siting Report	5 days	9/22/98	9/28/98
4		Caltrans Review	1 day	9/29/98	9/29/98
5		Revise Report	1 day	9/30/98	9/30/98
6		Plaintiff Review	5 days	10/1/98	10/7/98
7		Finalize Report	2 days	10/8/98	10/9/98
8					
9		**DESIGN REP0RT**	**53 days**	**9/29/98**	**1/14/99**
10		Design Criteria Report	6 days	10/1/98	10/8/98
11		Plaintiff Review	10 days	10/13/98	10/26/98
12		Hydrology Map	50 days	9/29/98	12/14/98
13		Prepare Draft Report	31 days	10/29/98	1/14/99
14					
15		**DESIGN**	**67 days**	**10/8/98**	**3/1/99**
16		Survey	15 days	10/8/98	10/28/98
17		Geotech Investigation	10 days	10/19/98	10/30/98
18		Draft Design	35 days	11/2/98	1/22/99
19		Draft Specifications	16 days	12/1/98	1/22/99
20		Caltrans/DHS/VCD Review	10 days	1/25/99	2/12/99
21		Plaintiff Review	10 days	1/25/99	2/12/99
22		Finalize Design/Specs	5 days	2/15/99	3/1/99
23					
24		**ENVIRONMENTAL**	**70 days**	**10/29/98**	**3/25/99**
25		CEQA Process	20 days	10/29/98	11/25/98
26		Coastal Zone Permit Process	10 wks	11/30/98	3/25/99
27					
28		**CONSTRUCTION**	**96 days**	**1/12/99**	**6/10/99**
29		Encroachment Permit	20 days	1/12/99	2/15/99
30		Advertise	1 day	3/1/99	3/1/99
31		Bid	10 days	3/2/99	3/15/99
32		Ct Notice to Proceed	5 days	3/16/99	3/22/99
33		Award	1 day	3/26/99	3/26/99
34		Execute contract	3 days	3/29/99	3/31/99
35		Construction	50 days	4/1/99	6/10/99
36					
37		**OMM PLAN**	**82 days**	**1/12/99**	**5/20/99**
38		Draft Vol I Addendum (RBF)	15 days	1/12/99	2/8/99
39		Caltrans Review	5 days	2/9/99	2/15/99
40		Final Draft	2 days	2/17/99	2/25/99
41		Plaintiff Review	10 days	2/26/99	3/11/99
42		Finalize Vol I Addendum	5 days	3/12/99	3/18/99
43		Draft Vol II Addendum (KLI)	15 days	3/19/99	4/8/99
44		Caltrans Review	5 days	4/9/99	4/15/99
45		Final Draft Vol II	5 days	4/16/99	4/22/99
46		Plaintiff Review	10 days	4/23/99	5/6/99
47		Final Vol II	10 days	5/7/99	5/20/99



APPENDIX C: ESTIMATING POLLUTANT LOADINGS

ESTIMATING POLLUTANT LOADINGS AND BMP EFFICIENCY

Background

This section provides a brief literature review and background information on constituent loading calculation and estimation techniques which were used in selecting the appropriate methods for analyzing data obtained from the BMP monitoring program. Several documents outlining constituent load estimation methods and/or related topics were reviewed. The techniques are generally very similar, and a few representative documents will be briefly discussed here. Summaries from a few key studies are also provided.

The EPA's Nationwide Urban Runoff Program (1982) measured constituent concentrations at 85 sites for 200 storms throughout the United States, and the results were published in 1983. This study is probably the most comprehensive study of its type available. The study began by testing the assumed log-normal distribution of the data, which was determined to be valid. Site specific rainfall/runoff characteristics were found to be very important to the results. Federal Highway Administration (FHWA) has outlined a procedure for estimating impacts to streams and lakes receiving highway stormwater runoff in a three volume report entitled as, "Pollutant Loadings and Impacts from Highway Stormwater Runoff" (1990). Volume III of the report, entitled as "Analytical Investigation and Research Report", tested the validity of the lognormal distribution, which is then used in presenting the methodology used in data analysis. Results indicated that when an underlying population has a lognormal distribution, the mean and variance of the population should be obtained by computing the mean and standard deviation of the logarithmic transforms of the data.

Volume I of the FHWA 1990 report, entitled as "Design Procedure", provides worksheets to calculate runoff and constituent loading parameters from inputs such as drainage area, rainfall data, streamflow, Event Mean Concentration (EMC), and soluble fractions (defined as soluble fraction of each measured constituent). One worksheet is provided to calculate runoff from the site characteristics, and another is given to calculate constituent mass load in pounds per year from highway runoff characteristics. The annual mass load is computed according to the following equation:

$$AML = EMC * MVR * N * 0.00006245$$

where: AML is the annual mass load in pounds per year,
EMC is the event mean concentration in mg/L,
MVR is the mean volume of runoff from a storm event at the specified site in cubic feet,

N is the average number of storms per year,
0.00006425 is a conversion factor to convert results to annual mass in pounds per year,

The Flint Creek Watershed Project (1995) was initiated by the Morgan County Soil and Water Conservation District to improve and protect the water quality of Flint Creek, located in Northwestern Alabama. To determine the best approach, annual constituent loadings were estimated for Total Suspended Solids, BOD5, Total Kjedahl Nitrogen, Phosphorous, and Nitrogen for land uses including, industrial and commercial, residential, cropland, pasture, and grazing type uses. For industrial and commercial land uses, the following equation was used to estimate annual constituent loads:

$$M = R * K * A * C * 0.227$$

where: M = Constituent Loading (lbs/yr)
R = Rainfall (in/yr)
K = Runoff Coefficient
A = Drainage Area (acres)
C = Pollutant Concentration in Runoff (mg/L)
0.227 = Unit Conversion Factor

The Santa Monica Bay Restoration Project included annual estimates of constituent loading to Santa Monica Bay from stormwater runoff. The constituent loadings were tabulated for various land uses, including residential, commercial, industrial, and open spaces. Water quality measurements were taken at 22 selected locations. Pollutant loads were obtained by multiplying the stormwater flow rate by a constituent concentration. The runoff is affected by land use, so the following load estimating model was used to account for variation in land use:

$$\text{Load} = \Sigma\, M_a * X_a$$

where: M is concentration of constituents for land use a, and
X is runoff from land use a.

Finally, in review of the “1996-1997 Caltrans Detention Basin Monitoring Plan”, NRDC outlined a loading estimation method which is very similar to the FHWA method discussed above and recommended to arrange the loading calculations on one or more computerized spreadsheets for convenience (November 12, 1996 Memorandum from Richard Horner to Ed Dammel and Bob Smith). The recommended method can be used to estimate wet season and annual loading given calculated event loadings. If possible, NRDC suggested to obtain continuously recorded local flow data and a series of representative local EMC readings. Assuming log-normal distribution of EMCs, the mean of the EMCs can be calculated using an applicable statistical relationship. In addition to the constituent load estimations, NRDC recommended that BMP efficiencies be evaluated from a comparison of effluent and influent loadings (over a period of time) from the following relationship:

Efficiency (%) = [(Loading in - Loading out)/Loading in] x 100

Methodology

The recommended methodology for estimating effluent and influent constituent loadings for the subject detention basins was obtained from FHWA report *Pollutant Loadings and Impacts from Highway Stormwater Runoff.* This method is very similar to the NRDC recommended procedure discussed above. Caltrans and NRDC acknowledge the limitations of the procedure when it is applied to small data sets. Statistical analysis will be performed for each year of the program and for the overall monitoring period of two years. Other numerical techniques will be employed as needed to make the most effective use of the data set.

<u>Estimating Pollutant Loading</u>

The following is a step-by-step guide in estimating constituent loadings using the FHWA method:

1. Collect stormwater runoff samples from five representative storms.

2. Analyze water samples for desired water quality parameters and obtain EMCs.

3. Tabulate EMCs.

4. Measure runoff volume per storm. If problems occur with obtaining flow data, multiply runoff coefficient (unitless) by watershed area (in acres) and rainfall depth per storm (in inches) to obtain runoff volume (acre-in).

5. Convert runoff volume from acre-in to liters using the conversion factor: acre-in = 102,790 liters.

For single event constituent loading calculation, perform Steps 6a and 7a, otherwise skip to Step 6b:

6a. Multiply EMCs (in μg/l or mg/l) from Step 2 by runoff volume (in liters) from Step 5 to obtain constituent load in μg or mg.

7a. Convert constituent load from μg or mg to pounds (lbs) using the conversion factors: 1 mg = 0.00000220 lbs and 1 μg = 0.00000000220 lb.

For average wet season loading estimations, perform Steps 6b and 7b:

6b. Take natural log of EMCs from Step 2.

7b. Compute mean *(μ)* and variance *(s^2)* of natural logs obtained from Step 6b from the following equations:

$$\mu = \frac{x}{n}$$

$$s^2 = \frac{\left(n \quad x^2 - \left(\quad x\right)^2\right)}{n(n-1)}$$

where: x is the natural log of EMCs.
Σx represents the summation of data points (x).
n is the number of data points (x).

8. Compute expected value a (also known as mean of the EMC) using the following formula:

$$a = e^{(\mu + s^2/2)}$$

9. Compute upper and lower confidence limits x_{hi} and x_{lo} from μ, s, and standardized normal deviate, z, using the equation:

$$x = e^{(\mu +/- zs)}$$

The value of z corresponds to a given probability of exceedence, which can be converted to a confidence level. For a confidence level of 90%, for example, the z value corresponding to 0.90 is 1.28. Values for z can be obtained from a standard normal distribution table.

10. Compute runoff volume per wet season by multiplying runoff coefficient (unitless) by watershed area (in acres) and rainfall depth per wet season (in inches) to obtain runoff volume (acre-in), and converting to liters by using the conversion factor from step 5 above.

11. To obtain expected constituent load in the wet-season, multiply expected value (mean of the EMC) from Step 8 by the runoff volume obtained from Step 10. Convert to pounds (lbs) using the conversion factor provided in Step 7a.

12. To obtain the 90% confidence limits for expected constituent loadings in the wet-season, repeat Step 11, substituting the confidence limits from Step 9 for the expected value.

Computing BMP Efficiency

As mentioned previously, BMP (detention basin and CSF) efficiencies may be evaluated by comparing effluent and influent loadings over the entire wet season from the following equation:

$$\text{Efficiency (\%)} = [(\text{Loading in} - \text{Loading out})/\text{Loading in}] \times 100$$

For the detention basins, since the residence times are expected to be fairly long (longer than a typical event duration), cumulative loadings over a series of events should be used in estimating BMP efficiency. When using a multiple events for basin efficiency calculations, it is necessary to have a complete loading record or representative loadings. Since the CSF residence times are expected to be fairly short and the CSFs should be operating under steady state conditions, the EMC (or the mean EMC for a series of events) can be substituted for loading in the efficiency equation above.

APPENDIX D: PROJECT STAGING PLAN

District 7 BMP Retrofit Pilot Projects
Project Staging Plan

OVERVIEW

It is recognized by Caltrans and Plaintiffs that technical or construction issues may arise in the development of the BMP Retrofit Pilot projects that would necessitate the delay in the delivery of a pilot project. Accordingly, the project master schedule has been developed in two forms, a primary or target schedule, and a contingency schedule. The three-year schedule with monitoring starting in the Fall of 1998 is a target schedule for all of the BMP Retrofit Projects. A second, or contingency schedule has been developed that indicates monitoring beginning in the Fall of 1999 rather than 1998. The target schedule would allow for two monitoring seasons, while the contingency schedule will cover one monitoring season. Both schedules are consistent with the Consent Decree requirement of completing construction of five retrofit projects before June 30, 1999. It is expected that some of the pilot projects may be delayed due to unforeseeable circumstances, and would then proceed based on the contingency schedule time-frame. Due to the research nature of this program, all of the dates shown in the master and contingency schedules are considered estimates, and with the exception of those expressly defined in the Consent Decree, will be subject to revision as the program proceeds.

PROJECT STAGING

Three ‘decision points’ have been identified where discrete pilot projects may be shifted from the primary schedule to the contingency schedule. Discussion of the projects relative to the stated criteria will be initiated in the March 30, 1998 status meeting. Each of these decision points, along with the criteria to be used to identify candidate contingency schedule projects is given as follows:

Decision Point No. 1- Post Design, Preconstruction

Date: June 10, 1998 (PSE Projects)
June 10, 1998 (Procurement Projects)

<u>Decision Point Criteria</u>

- Pilot has fundamental design/siting flaw
- Design/plans/specifications not complete

- Siting not complete

Discussion

This will be the primary decision point for deferring pilots to the Contingency Schedule. Pilots that proceed beyond this decision point will be 'committed' for the bid and construction process, with relatively fewer options for delay at the second decision point. Issues indicating delay at this decision point will be design related, focusing on incomplete, delayed or other design problems. Pilots may be delayed within this decision point time frame should bid problems occur, such as contractor bids not in substantial agreement with the engineer's estimate.

Decision Point No. 2 – Pre-monitoring

Date: November 18, 1998

Decision Point Criteria

- Pilot construction delayed (construction delays)
- Pilot construction flawed
- Pilot not ready for monitoring
- Delays/problems installing/configuring sampling equipment
- Bid process problem

Discussion

This decision point will occur post-construction but prior to commencement of monitoring. Primary issues indicating delay to the contingency schedule at this point are related to the suitability of the site to begin monitoring. Examples could include incomplete construction, site not properly stabilized, incomplete growth of biofilters, or problems with monitoring equipment. Pilots may also be delayed within this decision point time frame should bid problems occur, such as contractor bids not in substantial agreement with the engineer's estimate. Pilots delayed at this decision point would track with the monitoring portion of the Contingency schedule once construction problems were completed. Note that no substantial construction of the pilots will occur during the winter season (December through March).

Table D-1: Designation (PS&E or Procurement)

Project/ Plaintiff	Description	Target or Secondary Watershed	Location	Designation
1	**Extended Detention Basins and Biofilter**			
Stipulation & Decree	Site 1: Extended Detention Basin	primary	Interstate 15 and Highway 78 Interchange	PS&E
Decree	Site 2: Extended Detention Basin	primary	Northbound Interstate 5 and Manchester Avenue	PS&E (contin)
Stipulation & Decree	Site 3: Biofiltration Swale	primary	Southbound Interstate 5 at Palomar Airport Road	Procurement
2	**Infiltration Trench and Biofilters**			
Stipulation & Decree	Site 1: Infiltration Trench	primary	Carlsbad Maintenance Station	Procurement
Stipulation & Decree	Site 1: Biofiltration Strip	primary	Carlsbad Maintenance Station	Procurement
Stipulation & Decree	Site 2: Biofiltration Swale	primary	Highway 78 Eastbound at Melrose Place	Procurement
3	**Extended Detention/Infiltration Basins**			
Stipulation & Decree	Site 1: Extended Detention Basin	secondary	Interstate 5 and Highway 56	PS&E
Stipulation & Decree	Site 2: Infiltration Basin	primary	Interstate 5 Southbound and La Costa Blvd.	PS&E
4	**Wet Basin**			
Decree	Site 1: Wet Basin	primary	Interstate 5 Southbound at Manchester Avenue	PS&E (contin)
5	**Media Filters**			
Stipulation & Decree	Site 1: Media Sand Filter	primary	Escondido Maintenance Station	Procurement
Stipulation & Decree	Site 2: Media Sand Filter	primary	Interstate 5 Southbound at Highway 78 Park/Ride	Procurement
Decree	Site 3: Media Sand Filter	primary	Interstate 5 Northbound at La Costa Blvd. Park/Ride	Procurement
Stipulation & Decree	Site 4: Compost Filter	secondary	Kearny Mesa Maintenance Station	Procurement

Notes: Decree=Consent Decree; contin=contingency schedule

TABLE D-2: PS&E PROJECT SCHEDULE

PS&E PROJECTS	**DISTRICT 11 PACKAGE 1 (RBF) PS&E**
PS&E SUBMITTAL TO DISTRICT (MEETING)	3/16/98
DISTRICT COMMENTS TO CONSULTANTS (MEETING)	3/31/98
REVISED PS&E TO DISTRICT OFFICE ENGINEER, NRDC, and EPA (District 11)	**4/7/98**
NRDC and EPA COMMENTS TO CALTRANS	**4/14/98**
DISTRICT OFFICE ENGINEER COMMENTS TO CONSULTANTS	4/21/98
FINAL PS&E TO DISTRICT OFFICE ENGINEER	4/28/98
PS&E	**5/5/98**
READY TO LIST (RTL)	5/11/98
Supplemental Report - Complete Design Assumptions Submitted to NRDC	**6/1/98**
1st DECISION POINT (Post Design - Pre-Construction)	**6/10/98**
ADVERTISE (ADV)	6/22/98
BID OPENING (BO)	7/16/98
AWARD (AW)	8/6/98
EXECUTION (EX)	8/13/98
BEGIN CONSTRUCTION (BC)	**8/18/98**
Supplemental Report - Construction Status and Problems Submitted to NRDC	**11/11/98**
2nd DECISION POINT (Pre-Monitoring)	**11/18/98**
START STORMWATER MONITORING	**12/1/98**

TABLE D-3: PROCUREMENT PROJECT SCHEDULE

PROCUREMENT PROJECTS	**DISTRICT 11 PACKAGE 2 (AEI-CASC) Procurement**
SUBMITTAL TO DISTRICT (MEETING)	3/16/98
DISTRICT COMMENTS TO CONSULTANTS (MEETING)	3/31/98
REVISED SUBMITTAL TO DISTRICT, NRDC, and EPA (District 11)	**4/7/98**
NRDC and EPA COMMENTS TO CALTRANS	**5/1/98**
PACKAGE TO ENCROACHMENT PERMITS	5/8/98
PERMITS ISSUED	5/15/98
Supplemental Report - Complete Design Assumptions Submitted to NRDC	**6/10/98**
1st DECISION POINT (Post Design - Pre-Construction)	**6/19/98**
BEGIN CONSTRUCTION (BC)	**8/1/98**
Supplemental Report - Construction Status and Problems Submitted to NRDC	**11/11/98**
2nd DECISION POINT (Pre-Monitoring)	**11/18/98**
START STORMWATER MONITORING	**12/1/98**